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EDITORIAL

CURRENT news items would indicate that in ranging the qualifications for managing an international exposition in the order of their importance, a good stomach takes precedence over a good head.

REPORT that the Pacific Gas & Electric Company has voluntarily retained Mr. Bion J. Arnold to investigate and recommend methods for improving the service given by its traction interests in the city of Sacramento is a healthy indication of the new attitude assumed by public-service corporations toward the people whom they serve. If all public utilities would follow the same policy, anti-capitalistic agitators would be deprived of their chief weapon.

MONROE street bridge at Spokane, which is the subject of an interesting article by Mr. Morton Macartney in this issue, presents the pleasing result of a happy combination of engineering skill with architectural beauty. So many engineering structures are unnecessarily ugly, that it is a pleasure to note that the engineers and architects responsible for the design have handled the subject from an artistic as well as a utilitarian standpoint, with results greatly to their own credit as well as a pleasing exemplification of the civic progress of the city of Spokane.

SLOT MACHINES have been prohibited in nearly every section of the United States by reason of their employment almost exclusively as gambling devices. Nuremberg, in Germany, has achieved a result, however, in direct antithesis to that obtained in the United States by adopting automatic machines as a means for encouraging the habit of saving among school-children. The machines in use, upon the deposit of a 10-pfennig piece, deliver a gummed 10-pfennig savings-stamp. The Nuremberg city savings bank, which is operating the machines, furnishes without charge a savings card, five inches square, marked off in 20 squares, to which the stamps are to be attached. When the card is completely filled, it represents a value of 2 marks, and upon presentation at the bank the depositor's account is credited with that amount. One of these machines has been placed in the corridor of the bank offices, and two others in the corridors of high school buildings. The machines were installed in the hope that they might induce children to save their 10-pfennig pieces rather than spend them for candy, ice cream, and other delectable compounds, of which it is evident German children are just as fond as those in America. If the experiment proves successful, more of the automatic machines will be installed throughout the German Empire. Germany has carried the use of automatic machines of one kind or another to a high stage of development, and has found that the combination between salesman and cash register is very efficient for selling and distributing merchandise of all kinds. Stamps, post cards, railway tickets, liquid and solid refreshments of all kinds can be bought anywhere in Germany by the

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mere deposit of a suitable coin in a slot provided for that purpose.

A Communication

The Editor:

In your September number, on page 432, I observe an editorial dealing with a report by Messrs. Purcell, Sanders, Loomis, and myself to the Association of American Portland Cement Manufacturers. It is evident that you have been given wholly wrong information, and that the person who gave this information knew at the time he was not stating the truth. It is, to say the least, a remarkable thing that politics should be referred to in connection with one's duties as an engineer. I desire to emphatically deny that I am a Socialist, or a member of the Socialist party, and since the statement has been erroneously made that I am, I feel that I may be permitted to state my political position without an apology. I was a Democrat until 1896, when Mr. Bryan launched his radical ideas, and at that time changed to the Republican party with thousands of other conservative Democrats in this city. Since then, I have been a member of the regular Republican party and still am so, not having even gone so far as to 'bolt' the party with those who organized the so-called progressive party and adopted most of the radical ideas entertained by Mr. Bryan and Mr. Debs. I can also say for all of my associates in the investigation of the Los Angeles aqueduct cement that none of the three are, or have been, Socialists. Concerning the side remark in the report that we observed many other fundamental defects in the Los Angeles aqueduct, this was inserted after due deliberation for fear that some one might say that the only criticism we could make of the aqueduct was the cement manufactured by the city, and that we otherwise approved it. As a matter of fact, we found so many other glaring defects, which your space here prevents enumerating, that at some future time, when these become apparent, we might be blamed for not in some way calling attention to them. The so-called side remark in the report referred to in your editorial was, therefore, inserted merely to safeguard ourselves. It must not be inferred that our report was made for any commercial organization engaged in the sale or manufacture of cement. It was made for the Association of American Portland Cement Manufacturers, which is not a commercial organization, but purely scientific. The employment was made without any communication on the part of the Association as to what finding on the subject would be acceptable to it, and our work was carried on in this manner. Omitting myself entirely from all consideration, the fact that Mr. W. H. Sanders, consulting engineer of the U. S. Reclamation Service, Mr. Gervaise Purcell, a leading consulting engineer of this city, and Mr. Chester B. Loomis, another younger but very able engineer, participated in the investigations and making of the report, must set aside any suspicion as to the fairness of our findings. So far as the quality of the 'tufa' cement work on the aqueduct is concerned, I quite agree with you that a proper test will tell, for if the full capacity of the aqueduct is ever carried through it for any considerable length of time, so much of it will be washed out that I believe it will even surprise those of us who have carefully investigated the matter. The 'tufa' cement concrete work will of course hold water, as it is quite impervious, but it is not sufficiently hard to

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withstand erosion. If the cement manufacturers of this country should now desire to eliminate the municipal manufacture of cement, this would be an extremely easy matter, as the Monolith plant is being offered for sale at about one-half its original cost, due, as I firmly believe, to the fact that it never has manufactured any portland cement which will pass the specifications of the American Society for Testing Materials and the U. S. Bureau of Standards. In closing, I desire in justice to Mr. Loomis to correct the statement that he is a discharged employee of the Los Angeles aqueduct. Mr. Loomis left the aqueduct because he did not approve of the irregular and inferior work being done at many points, and was thereafter employed by Mr. Mulholland to erect a pumping plant for the Dominguez Water Company, under Mr. Mulholland's direction as consulting engineer. Had he been discharged, Mr. Mulholland would not have employed him on this important work after he left the aqueduct.

Respectfully yours,

F. C. FINKLE.

Los Angeles, Cal.,
September 14, 1912.

[Mr. Finkle is of course the best judge of his political affiliations, and we have evidently been misled by the fact that he acted in an advisory capacity for the Socialist members of the committee that investigated the aqueduct affairs.—EDITOR.]

Oil Production

Rumors of an impending increase in the price of oil at the well bring joy to the hearts of California producers. In March last a new scale was inaugurated by both the Standard and Union companies, establishing a price to producers of 35 cents per barrel on the low-gravity oils, an increase of 5 cents, with a corresponding increase on the lighter oils. There was no justification for the price of 30 cents per barrel prevailing before the increase of last March, other than the enormous overproduction to which the famous Lakeview gusher was the chief contributing factor. The Associated Oil Company has long been a Southern Pacific subsidiary, but the railroad management has apparently been willing to let things run along in the same old groove, until, in anticipation of Government suits for dissolution of the Harriman group, the eggs were unscrambled to the extent of dividing the empire, presided over by the late Mr. Harriman, into a number of independent principalities, each with an operating head and the usual quota of officers. Mr. Sproule, since his elevation to the presidency, has been swinging the axe right and left. Many heads, both high and low, have already dropped in the basket, while many more employees are said to have been marked for decapitation. Dissatisfaction with the past management for the one cardinal sin for which there is no forgiveness—namely, that it has not made money and that there have consequently been no dividends—is said to be the cause of the many changes. That there has also been enormous waste and extravagance in the early production of oil, no one can deny. There is some excuse for such things during the development period, in fact the development of any natural resource seems to be inevitably accompanied by feverish haste to produce and 'cash in' rather than develop with an eye to the future and the production of best results over the longest possible period. The introduction

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of engineering and engineers into the oil industry is comparatively recent—so recent, in fact, that there are carping critics who say it has not yet been accomplished. The trained engineer who goes into the oilfields, heart-whole and fancy free, unhampered by tradition, marvels at the crudity of the apparatus, and is aghast at the waste and extravagance in the methods in vogue for the generation, application, and transmission of power. Low-pressure steam is generated in central boiler plants and sent out in buried pipes for distances often in excess of 1000 feet to operate slide-valve engines. The fields are dotted with feeble puffs of exhaust steam, which, while undoubtedly picturesque, are an eye-sore to engineers whose life work is the elimination of waste. Power is transmitted to the drills or pumps through home-made calf and bull-wheel outfits to crude pumping-jacks, while the hoisting drums used for raising tools or bailers are made of wood, and with shafts sometimes made of gas-pipe revolving in journals consisting of two pieces of timber worked out for the shaft and bolted together. In justice to oil-pumping practice, we can say that the bearings are occasionally greased. It is doubtful whether more than 10 per cent of the power generated by the boilers is converted into useful work at the well. Many oil producers, like the small boy who wished that his father kept a candy store so that he could get his candy for nothing, charge themselves little or nothing for oil consumed in the field. Many more of them have their own way of figuring the cost of producing oil, although data of any kind on this subject are difficult to obtain. The following figures, published in the *Calfornia Oil World* represent a fair average of cost of production, barring a few exceptional cases.

Average first cost	$0.40
Storage and transportation	0.15
Interest and taxes	0.08
Evaporation and seepage	0.07
Total, per barrel	$0.70

On this showing it would appear that the oil producers need more than 40-cent oil before they will feel like bidding dull care good-bye. There is only one other way to improve conditions, and that is to decrease the cost of production. One-cent decrease per barrel of oil would mean over $750,000 per year to the oil producers of this state. *Western Engineering* is preparing to publish a series of articles, each one written by an acknowledged authority, dealing with the application of electricity to drilling and pumping in the oilfields. This will embody what, as far as we know, will be the first authoritative data made public on this subject, and will, we hope, open new lines of thought as to the most economical method for the production of oil. We are firmly of the opinion that the application of this method will result in an enormous saving in the cost of production. The figures show almost startling results, so much so in fact that it is surprising that this method has not made more headway. However, this is a question that each operating company must answer for itself. It is to be hoped that the publication of this matter, of which the cost of obtaining the electrical apparatus determinations alone cost the Westinghouse Company nearly $30,000, will occasion discussion through which all oil producers will benefit. The interchange of ideas with regard to the improvement of oil-production methods cannot do other than benefit all concerned.

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REVIEW OF THE MONTH

PRESIDENTIAL campaign is at its height, and the 'spellbinder' stalks abroad in the land. Political news takes precedence over all other, while the fitness and unfitness of rival candidates for the highest office within the gift of the people are set forth from press and rostrum. Business, contrary to the usual turn of events at such times as these, seems to be accelerated rather than retarded. General industrial development is the order of the day, and every sign indicates that we are beginning an era of general prosperity which is characterized by sound creative effort rather than the craze for indiscriminate speculation coincident with the so-called 'good' times of the McKinley administration. The West is more than holding its own in the race for progress, and there is every evidence at hand that capital is beginning to realize the vast potential possibilities in the development of the territory adjacent to the Pacific ocean.

INCREASED activity in the development of the California oilfields is shown by the announcement that has come from New York of the organization of the California Petroleum Corporation, with an authorized capitalization of $35,000,000. This company has taken over 80 per cent of the stock of the American Petroleum Company and the same amount of the American Oilfields of California. These are generally known as the Canfield-Doheny properties, and include the Niles Lease Company and the Midlands Oilfields of California. Mr. Ralph Arnold has reported on the properties and states that they include in all over 18,816 acres, situated in the Coalinga, Midway, and McKittrick fields, of which 3786 acres has been proved. There are 110 producing wells, of which the present output is approximately 500,000 barrels per month. This will make the sixth large producing company in the California fields. The Standard, Associated, Union, and Independent Producers Agency have been established for several years, while the fifth, the General Petroleum Company, is making rapid strides in the construction of extensive surface equipment that will make it a factor to be reckoned with in the competition for trade.

EXCELLENT progress is being made toward completion of the Los Angeles aqueduct. The four-mile siphon for Antelope valley has been completed and is now partly filled with water. This is one of the longest siphons in the world and is composed of a steel pipe 10 feet in diameter, 15,596 feet long, and more than 3000 feet of concrete pipe. The length over all from tunnel to tunnel is 21,767 feet. The cost of the steel pipe alone was $225,000, including 3324 tons of ⅜-inch steel plate. It is believed that the cost of this siphon establishes a new record. It is less than 3¼ cents per pound.

THE aqueduct investigation board has concluded its labors and submitted a report which may be classed among those things which are important if true. The findings, in brief,

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state that the aqueduct project was unnecessary for the reason that enough water for a population of one million people could be developed within the water area of the Los Angeles river, that the Owens river water is not fit to drink, that only half of the expected 20,000 inches will be brought to the city, and that this half will be fit only for irrigation purposes. The report further states that the city must spend $23,500,000 additional to make the water and power projects efficient and profitable. Complaint is made of the secret methods employed by the Board of Public Works and the difficulty that the investigating committee had in obtaining accurate and reliable information concerning the aqueduct work. The committee has recommended that financial provision be made to carry out the aqueduct project as indicated by the estimate of Mr. B. F. McLouth. Mr. McLouth, in a separate report, has estimated that the cost of repairs and building of irrigation and power distribution systems will require, including the debt already incurred, $48,000,000 to place both water and power on a paying basis. Recommendation is made that the filtration galleries at Crystal Springs and the headworks be extended to provide filtration for the winter flow in order that the use of pumping plants during the months of heavy rainfall may be obviated. It is recommended that the proposed connection of the San Fernando reservoir with the city system be abandoned for the reason that this would establish the physical fact of a surplus water supply and thereby forfeit the city's exclusive right founded on necessity, to the underground waters of the San Fernando valley. Many minor recommendations are made, and the committee incidentally pays its respects to the Monolith cement plant at which the cost of manufacturing cement is declared to be excessive. The quality of the water is reported as good by chemical analysis, but bad from a sanitary standpoint. It would appear that the good people of Los Angeles undoubtedly have troubles of their own, and it must be indeed difficult for the voters, citizens, and taxpayers to reconcile the many attacks that have recently been made upon the aqueduct with the enthusiasm with which it was hailed during the early stages of its promotion and construction.

SPRING VALLEY Water Company has rejected the proposal made by the city of San Francisco to pay it $38,500,000 for all of its properties, but is willing, however, to accept that sum if allowed to retain about 2300 acres of land at Merced rancho and other lands. A summary of the various provisions contained in the alternate proposal offered by the Spring Valley company is as follows:

That the company be allowed to withhold 2300 acres of Merced rancho and other properties. That it be permitted to receive the impounded excess rate money now held in the bank, amounting to $1,300,000. That until the properties are finally turned over it be permitted to continue its rates with 15 per cent additional. That the offer shall not hold good after October 20 of this year unless the proposition to acquire the properties is submitted to popular vote by the Supervisors. That the Supervisors shall within thirty days after acceptance of the offer permit the company to take judgment in all pending litigation in the city. The purchase must be consummated by March 1, 1913. That all bonds not surrendered prior to the consummation of the sale be

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assumed by the city. That capital expenditures made by the company between now and the consummation of sale be added to the purchase price. That the city pay the company all municipal and private rates accrued up to the date of transfer, the city thereafter to be substituted in the stead of the company in all litigation over rates That the company only convey such title as it has.

The entire matter has been referred by the Mayor to the Board of Supervisors, who have taken the offer under advisement and are preparing a reply to the Spring Valley Water Company. The question that will have to be decided is the relation borne by the land that the water company desires to withhold to the value of the Spring Valley Water Company's properties as a source of water supply. It is a difficult matter to adjust, and also one upon which many varying opinions have been expressed. That San Francisco needs the property of the Spring Valley Water Company, there can be no doubt, as, regardless of the results of pending negotiations for rights from the Federal Government to develop the Hetch-Hetchy source of water supply, San Francisco's immediate necessities are of prime importance. It will take several years under the very best of circumstances to bring water from Hetch-Hetchy valley to San Francisco, while in the meantime the expected influx of people coincident with the opening of the Panama-Pacific exposition will render the problem of an adequate water supply an urgent one. It is greatly to be desired, therefore, that the city government on the one hand and the Spring Valley Water Company on the other get together and settle the question in a spirit of justice and equity so that the matter may be submitted to the voters and brought to a final conclusion.

EUROPE and Europeans are manifesting an increasing interest in the Diesel engine. Evidence of this is shown by the attendance at the Oil Engineering Exhibition which opened at the Olympia, London, on September 7. A large number of prominent oil producers have taken a great interest in this exhibition and have prepared notable exhibits dealing with their branch of the industry. Many interesting technical papers were read dealing with drilling and drilling systems, liquid fuel for marine and industrial purposes, standardization of fuel oils, and suggestions for the advance of the oil industry. The enormous growth of American foreign trade in petroleum and its products is occasioning much comment, and the possibility of Great Britain being cut off from a supply of liquid fuel in case of war has been the subject of much discussion in the public press and elsewhere. The fishing industry has already extensively adopted the oil-engine. A model fishing-boat has been constructed for display at the Fisheries Exhibition at Copenhagen. This vessel is 89 feet 9 inches long, 21 feet 4 inches beam, 10 feet 9 inches deep, and 8 feet 7 inches draft. The motor equipment consists of a 2-cylinder, 2-cycle engine, capable of developing 100 brake horse-power at 290 revolutions per minute, from which a speed of eight knots per hour will be obtained. An oil-driven passenger vessel has been built at Amsterdam which affords an interesting exemplification of the flexibility of this type of motor. This is a shallow-draft vessel, about 140 feet long by 26 feet beam. There are three decks, and the passenger-carrying capacity is about one thousand. The boat

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is a triple-screw vessel, each propeller being driven by a 90-horse-power motor, while a separate motor is provided for driving a generator for lighting and operating various other auxiliaries. The motors are placed forward under the passenger decks, while the oil supply is carried below the motors in the double bottoms and around the sides.

ANNOUNCEMENT has been made of the result of the activities of the California State Railroad Commission during the first eighteen months of its existence under the Public Utilities Act. The passage of the act was strongly opposed by many corporate interests within the state on the ground that it permitted an unwarranted interference in the administration of their business and conferred almost plenary power upon the men who formed the Commission. The report states that it has saved to the people of California more than $2,000,000 in the readjustment of rates charged for service by various public utilities. Mr. Athearn of the Southern Pacific Company takes the view, however, that this deduction from the earnings of the public-service corporations represents the interest on a possible investment of $40,000,000 for betterments which is thus automatically nipped in the bud. It therefore becomes necessary to provide funds for improvements and extensions by borrowing rather than by accumulating surplus earnings for this purpose. This act undoubtedly confers extraordinary powers upon the Commission, which seems to have made an earnest endeavor to administer justice according to its own viewpoint. The Commission can be a great power for good or evil, depending entirely upon the mental calibre and moral character of its personnel. They can eliminate such particularly vicious forms of 'cutthroat' competition as find expression in the inauguration of rate-wars in territory that is already well served and which are known to be conducted with the sole object in view of ultimately selling out to competitors at a good price. At the same time they can authorize a competing company to enter the field if it can be shown that the service afforded by the corporation already in possession has been wanting in any particular. It can withhold or grant permission to one company to buy out another. The issuance of financial paper by corporations is also subject to restrictions provided by this law, the administration of which comes within the jurisdiction of the Commission. Rebating by public-utility corporations is to be investigated, and franking privileges will undoubtedly be done away with. All of these things are an extension of the regulation of corporations first undertaken by the Interstate Commerce Commission and has been called Progressivism, Socialism, or even Anarchy, depending entirely upon what side of the fence one is on. It looks as though 'special privilege' were having a hard task to maintain the prerogatives it exercised in the past. It is altogether likely that Congress will ultimately pass similar laws dealing with corporations conducting an interstate business, and that such legislation will sooner or later be extended to cover public necessities as well as public utilities. No sane man wants to 'break' the corporations, and the majority of men desire no more than an effective regulation that will safeguard the interests of both producer and consumer alike, that each may have that which is his and bear his share of the burdens incident to this earthly existence.

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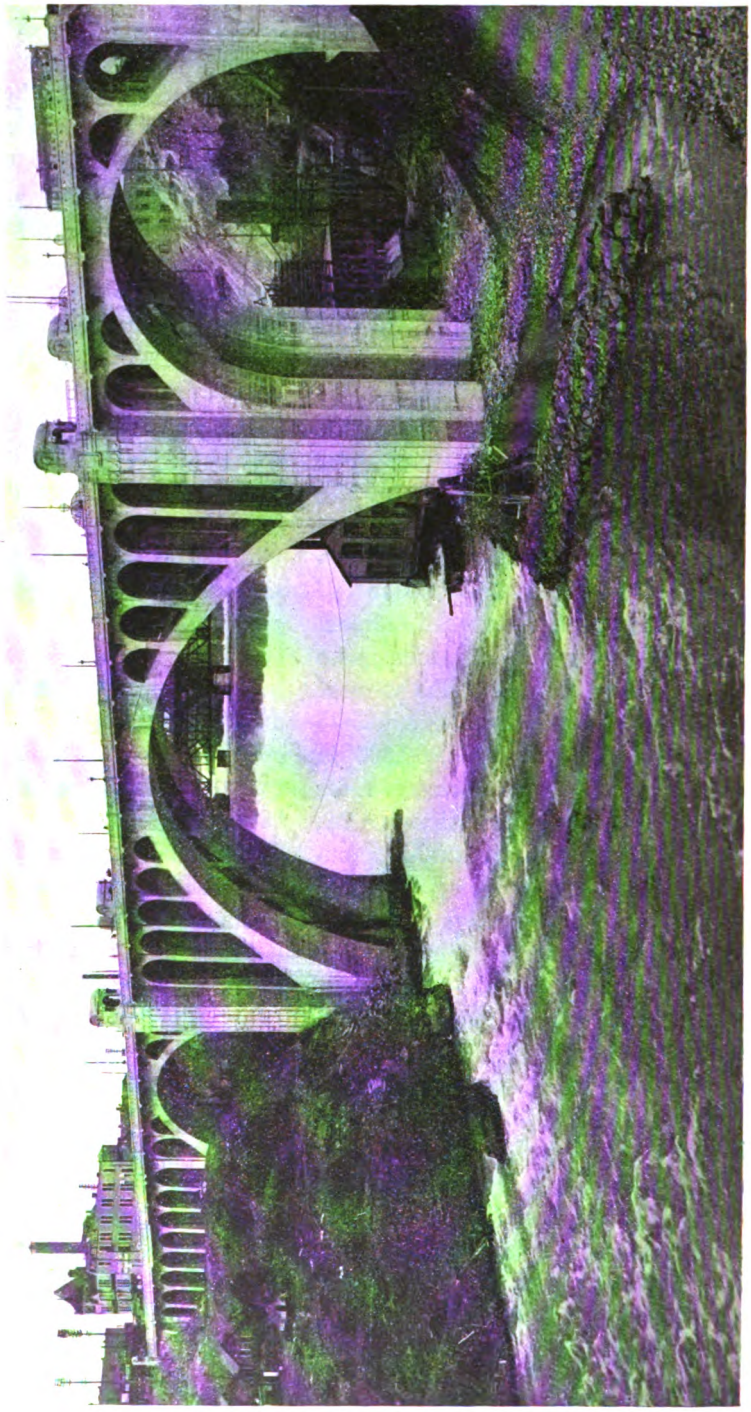

MONROE STREET BRIDGE AT SPOKANE.

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Monroe Street Bridge at Spokane

By MORTON MACARTNEY*

ON November 23, 1911, there was opened for traffic a concrete bridge across the Spokane river at Monroe street, Spokane, Washington. This bridge displaces the steel bridge which has done service for over sixteen years. The construction of the concrete bridge has presented some interesting problems, a brief discussion of which follows.

In 1902 Charles F. Bihler, of Tacoma, Washington, made an exhaustive examination of the steel bridge recommended repairs which amounted almost to a reconstruction. In 1905 or 1906 the bridge was condemned for street-car traffic, and in the fall of 1907 Wm. H. Burr, of New York City, submitted a report to C. Herbert Moore, mayor of Spokane, advising the construction of a concrete bridge. During the period between 1902 and 1907, preliminary studies of possible plans had been made by the Bridge Department of the city of Spokane, J. B. Strauss, and others. It was not, however, until the fall of 1907 that any active work was inaugurated in the design of the concrete bridge. At this time Charles McIntyre, city engineer, commenced the design of a concrete bridge. This design was carried along in a desultory manner and no real progress was made until J. C. Ralston was appointed city engineer in February 1908. The general features of this design were approved in January 1909, and the completion of the detail plans was ordered. These plans were consequently prepared and approved, and the entire design, with specifications for the construction of the bridge, was submitted to Wm. H. Burr, of New York, who checked and approved it, with a few minor changes.

Some agitation was carried on by the public and among the city officials as to the merits of contract work versus day labor, and considerable delay in starting the work was occasioned thereby. However, late in the summer of 1909, the City Council authorized the construction of the foundations and piers, and work was started on this portion of the bridge in August 1909. This work was also delayed and little progress made on account of lack of knowledge as to just how the plans of the work were to be completed. This necessitated delay in ordering the reinforcing steel, and in planning and arranging plant and equipment, and it was not until several months after this that the construction of the entire bridge was authorized. The main features of the design have been discussed in so many ways and so many times, that no attempt will be made here to give other than the principal factors and characteristics. The following is a short synopsis of the specifications upon which the design was based:

LOADS

Main.

Local members:

Cars—50-ton on each of the two tracks.

*City Engineer, Spokane, Washington.

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Highway.

Waddell's Class *A* for highways.

Floor slab — Standard 15-ton road roller given in Waddell's 'De Pontibus,' using 750 lb. per sq. in. in the concrete, also test the steel framing for the same roller, using a maximum fibre stress of 22,000 lb. per sq. in.

Sidewalks.

100 lb. per sq. in.

Arch Ring.

Street roads—100 lb. per sq. ft.
Cars—Same as above.
Sidewalk—80 lb. per sq. ft.

Impact.

Local members:
For highways—Waddell's highway impact.
For street-cars—Average of Waddell's highway and railway.
For sidewalks—None.
For arch ring—None.

Temperature.

20°F.

Wind.

20 lb. per sq. ft. on exposed surface.

FIBRE STRESSES

Arch Ring.

Concrete, maximum allowance, including live and dead load, wind, and temperature, 600 lb. per sq. in.

Floor.

Encased steel, 17,000 lb. per sq. in.

Floor slab concrete, 500 lb. per sq. in. (except as noted above) in reinforced concrete. p = proportion of steel in concrete = 0.7% in slab.

$$n = \frac{Es}{Ec} = 15.$$

The plans as presented were followed with very few minor changes, the principal changes being the elimination of the 100-ft. arch and the retaining wall at the north end of the bridge. For these were substituted 9 short arches, varying from 17 to 21 ft. in length. The general character of the surface of the ground indicated rock formation, but which, upon thorough examination, showed a marked downward inclination just north of the north end of the north 120-ft. span. Lying upon this rock was a deposit of glacial gravel, test pits in which revealed a depth of 40 to 50 ft. where the north abutment of the 100-ft. span would come. For this and other minor considerations, the short arches upon spread foundations were substituted. A minor change was made in the floor system of the bridge, altering slightly the manner of placing the street railway tracks on the bridge, and substituting for the asphalt pavement a 4-in. creosoted wood block pavement.

The construction of this bridge presented some new features which were taken care of in a very unique and well devised plan. The river channel passes with high velocity through a very deep rock canyon. The flow of the river varies from about 1400 sec.-ft. to nearly 35,000 sec.-ft., and for this reason, together with economic conditions, it was deemed advisable to use the old steel span in place to aid in the construction of the new work, so far as possible. For the purpose of handling the material for the new structure and also for the wrecking of the old steel span, two Lidgerwood cableways were installed, operating from the north end of the bridge. These cableways had 1000-ft. span, suspended from framed towers on both banks of the river, their capacity being about five tons working load, a hoisting speed of 200 ft. per second, and a traveling

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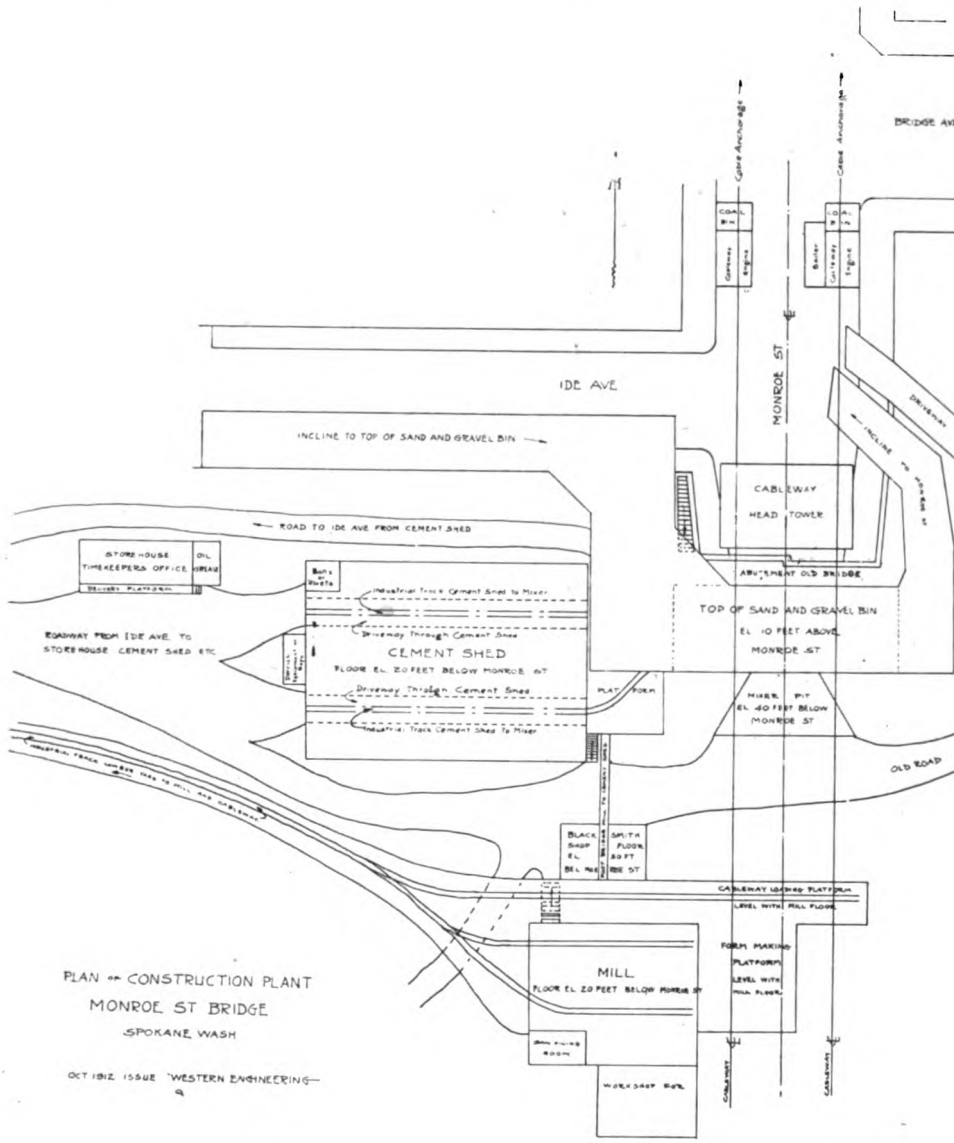
speed of 800 ft. per minute. The main cable was 2-in., with an endless cable of ¾ in., and a hoisting line of ½ in. which was afterward changed to ⅝ in. These cableways were placed parallel, 36 ft. centre to centre, and in this position were approximately over the centre of the two main ribs of the main or 281-ft. span. All material, both in the erection of the new bridge and in the wrecking of the old, was handled at the north end of the bridge, and the general plan lay-out at this end of the bridge is shown upon the accompanying sketch. The general features of this plan are better understood by reference to the panorama photograph of the bridge showing the concrete bins and mixer. The photograph shows the bins for sand and



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gravels, over which is a roadway or trestle, upon which material was delivered for the work, the sand and gravel being dumped into the bins below and the other material picked up from wagons and transported by the cableways to such positions as were desired. Much of the success that was attained in the construction of the bridge was due to the foresight of its designer, Mr. Ralston, and to his well designed plant and equipment. Very few changes in the execution of the work were made from those outlined in his plans, and such as were made were due entirely to developments which occurred in the work during its progress.

A 1½-yd. Haines gravity mixer was used, and proved very satisfactory for the mixing of the concrete in all places on the bridge except that portion of the concrete used in the thin spandrel walls, in the slabs and beams in the floor system, and in other places where the aggregate of the mixture was fine. Considerable difficulty was experienced in this condition in getting a well-mixed concrete, a condition which was not experienced as long as the crushed rock used had a great percentage of large particles in it. Contracts for material other than sand and gravel had been made prior to my taking up the work, and tentative arrangements were made for the rock and sand. These latter arrangements for material, however, were canceled, and the city put in a rock-crushing plant itself, letting contracts only for the sand. Rock and sand were hauled to the bridge, dumped into the bins, and discharged from these bins through hoppers to the mixer. All the operation of loading and unloading into the hoppers was done by gravity. The cement was run out on cars from the cement sheds to the west of the mixer and was unloaded by hand into the hoppers of the mixers. All the lumber for falsework, centring, and forms, was stored in adequate yards west of the bridge, and the supply yard was connected to the sawmill and loading platform by an industrial railway. Timbers were loaded on cars in the yards and were transported to positions under the cableways where they might be carried directly into place, or were hauled to the mill where they were framed, and then in turn carried to the cableways and transported into place. All cutting, sizing, and framing was done either in the mill or the yards, and bents for falsework framed and ready to put in place, and then were easily transported by cars and the cable to points of erection. All forms for concrete were assembled and constructed in panel-form, either in the sawmill or the supply yards. These panels were made interchangeable, so that they could be used a number of times in different portions of the work. This plan proved very satisfactory, and, in addition to being economical, was expeditious.

Derricks were used at points of advantage to assist the cableways in handling forms or timbers. This was very necessary because of the fact that the cableways were in use almost constantly during the pouring of the concrete. Two systems of holding forms in place were used, one using cables across and through the concrete work from one panel to a panel opposite; the other was that using anchor bolts with cast-iron washers imbedded in the concrete. The latter method, however, while having some advantages, presented rather a serious problem, due to the inability to put in concrete patches filling bolt holes in the con-

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crete. This was attempted in a number of ways, but almost every bolt hole shows at present in the surface of the bridge. Most of the centring, other than that used in the main 281-ft. arch, was local timber. The centring used in the large arch was chiefly made from Douglas fir cut in the vicinity of Seattle and Tacoma. A very good general idea of the falsework centring and forms used, other than that used in the 281-ft. arch, is shown in Fig. 2. All arches except spandrel were of voussoir construction and were poured with keys, and little or no difficulty was experienced in this operation. Constant care was exercised on the part of the foremen and engineers to obtain the maximum amount of spading and tamping of the concrete to insure an even and true surface.

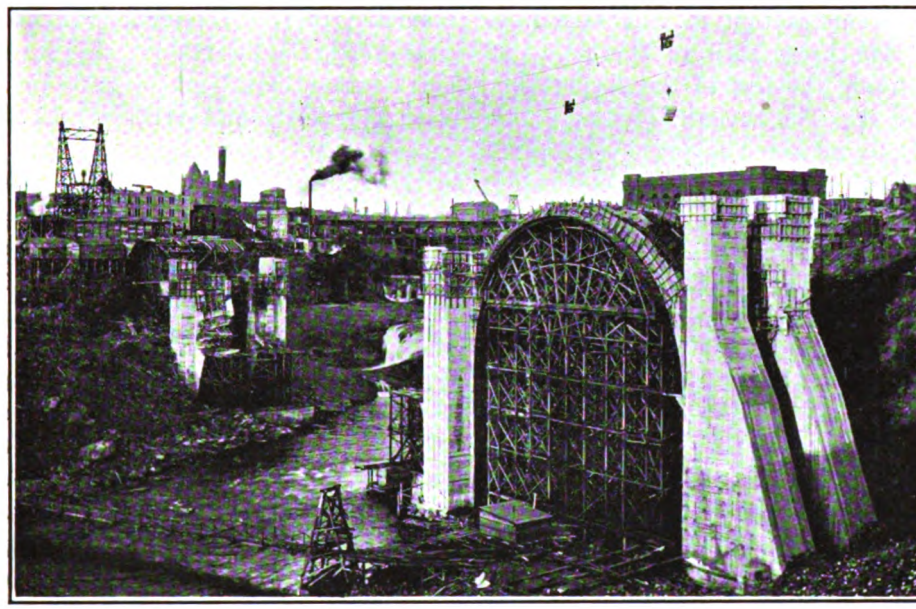

FIG. 2. FALSEWORK CENTRING AND FORMS.

Tongue-and-grooved lumber, surfaced two sides, was used on practically all the form-work below the floor system. All corners were filled with a triangular strip, and the forms were coated with soft soap to insure their removal without the adhesion of spalls of concrete. In the erection of the 281-ft. span, certain peculiar conditions required special treatment. It was not considered practicable to build up a falsework from the ground, on account of the depth of the river channel and two tailraces from the Washington water-power plant, and on account of the very smooth, shelving rock-formation in the bottom of the river. It seemed necessary to span this channel by some sort of a structure. The original design provided for a combination of wood and iron arch consisting of 7 ribs placed 3 ft. on centres. This centring provided for the forms for one arch-rib only, the intent being to pour one arch ring, allow it to harden sufficiently, and then to lower the centring, move it into position, and construct the other arch. This was erected upon sliding wedges similar to those used

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in the construction of the Rocky river bridge near Cleveland, Ohio. These wedges allowed for a movement of approximately 10 in. vertically in the falsework. On top of these wooden ribs were I-beams supporting 6 by 12-in. wooden ribs spaced 2 ft. centre to centre, on which the lagging was placed. Wedges were used between the arch members and caps, upon which these ribs rested, allowing for a sufficient adjustment in the curve of the arch. Construction of this falsework arch had progressed to the point of completing the last of the 7 ribs composing it. The seventh rib could not be finally adjusted in place until after the removal of the old steel bridge, which, up to this time, had been used in suspending the wooden arch in place until enough of its ribs had been connected to be self-supporting. The lateral bracing on the arch had been only partly put in place, and steel cables had been attached to the outside ribs to take care of the wind pressure in addition to the bracing. On July 20 the last piece of steel interfering with the construction of the seventh rib in the falsework arch had been removed, and in the forenoon of July 21 the workmen were placing the last piece preparatory to adjusting it into position. Shortly after noon a hard windstorm gathered in the west, the wind changing instantly from about 20 miles per hour southeasterly to about 42 miles per hour southwesterly, the squall being accompanied by a marked lowering of the temperature and heavy rain. The arch-ribs were demolished by the squall, the testimony of eye-witnesses being that the structure seemed to have been raised, after which all its members fell in one mass, northerly and westerly from the original position. Many conflicting ideas were expressed as to just what happened and just how it happened. Other than the loss of the falsework, little damage was done. A change in the manner of centring was decided upon, and the reasons for these changes were as follows: The old steel bridge from which the wooden arch centring had been suspended during its erection had been nearly entirely removed. In its removal it was found to be very badly corroded, the rivet holes in some cases being elongated to twice their diameter, the pin connections in many cases being badly rusted, and it was not deemed expedient or safe to re-erect the steel span. Without the steel span it was practically impossible to re-erect the wooden arch. The city at this time was contemplating the erection of a steel bridge about one-half mile farther down the river, and the plan was devised to use for a portion of the centring, the steel span, which could later be used in the other bridge, and for this purpose four steel trusses of 192-ft. span were designed. For the purpose of centring on the Monroe street bridge these four trusses were spaced 8 ft. centre to centre, giving a width of base of 24 ft. Several ingenious devices were used to erect these steel trusses. It was not possible, on account of the high stage of the water in the river, to place any supporting posts under the trusses. They were not intended to be erected without some such support, so this support was accomplished by eye-bars anchored in the concrete piers and abutments. The eye-bars supported the two outer trusses until assembled. Then the two inner trusses were constructed, being supported by the two outer ones. Little trouble was experienced in the erection of these trusses, the entire erection occupying only ten days, at a cost of $8.70 per ton.

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Above the upper chord of these trusses was arranged a system of falsework, designed to be as rigid as possible and giving a maximum amount of bracing for the narrow base. The arrangement and construction of this centring is shown very clearly in Fig. 3. In this illustration one arch ring has been poured and several of the spandrel columns supporting the spandrel arches have been completed, the centring and falsework being in position for the construction of the second arch-rib. These arch-ribs were poured in sections, keys being placed in the rib after the concrete had had its initial set, thus taking care of the change of position in the concrete sections of the arch-rib due to the deflection of the centring and falsework. It was interesting to note that this deflection amounted to only 1¾ in. at the crown of the arch under complete loading of the falsework, the maximum deflection occurring prior to the pouring of the last section of the arch ring. No difficulty was experienced in subsequent pouring of keys or the lowering or removal of falsework. The work of erecting the superstructure was carried along with little delay, and the bridge was finally open for travel November 23, 1911. The architectural treatment of the bridge was quite materially changed from its original design. The designer worked in collaboration with Messrs. Cutter and Malmgren, architects, and the architectural beauty is largely due to their combined efforts. The top of the piers originally had quite an elaborate design, and when the bridge was started it was intended to omit the construction of these details until a later time. However, in order to complete the work a less elaborate finish was decided upon and the bridge was completed in detail

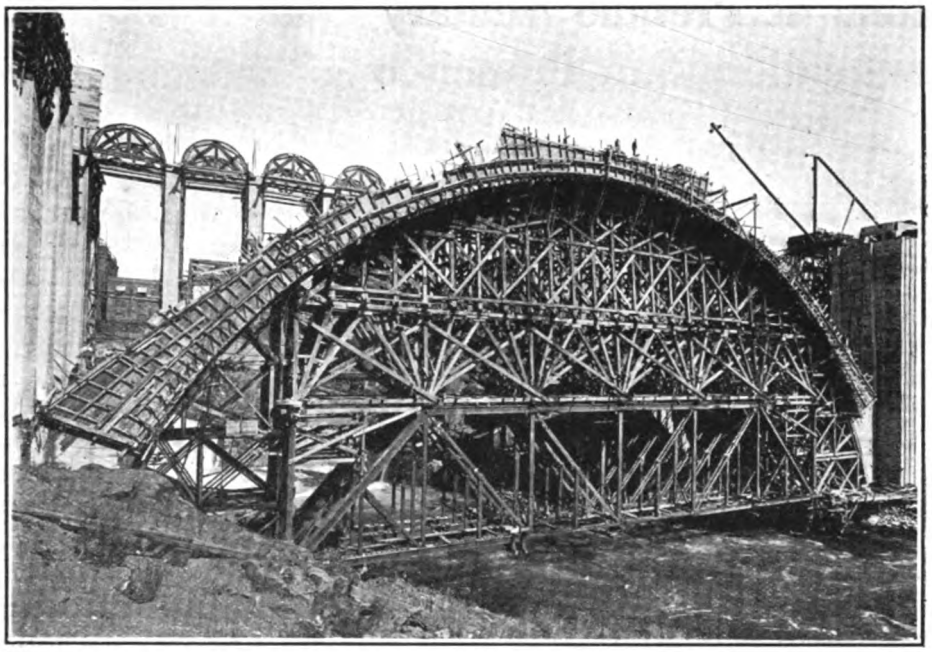

FIG. 3. READY FOR SECOND MEMBER OF THE BIG ARCH.

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before its opening. The work was carried on under the direct supervision of J. F. Greene and P. F. Kennedy, engineers in charge of construction, who were assisted by P. J. Sullivan as general superintendent of the work. The bridge contains 25,000 cu. yd. of concrete, and cost approximately $490,000. Twenty-three months of actual time were consumed in its construction. Two lives were lost during this period and two workmen were seriously injured. There was a total of 46 minor injuries.

Filters at Presidio Military Reservation, San Francisco

By C. F. BRAUN

THE Presidio Military Reservation of San Francisco comprises 1542 acres of land with a normal population of six thousand. The water required for domestic consumption, cavalry horses, and for garden irrigation amounts to about 2,000,000 gal. per day, all of which is developed within the reservation. Near the southern boundary, close to what is known as the Marine hospital, is a series of springs situated near the bottom of the sides of a shallow canyon. Their combined delivery is about 2,500,000 gal. per lay, the flow being practically constant independent of seasons. The water from these springs forms Lobos creek, which has a length of about 3000 ft. and empties into the bay of San Francisco. The canyon and creek are carefully protected by the post authorities from sewage pollution, and therefore provide a safe drinking-water supply. However, the water contains considerable organic matter, dirt, clay, and color, especially in the rainy season, when a considerable number of bacteria also are present, all of which make filtration desirable.

The water indicates a hardness of about 5° Clark and is therefore fair for steam-generator feed, not being productive of much scale, so softening is not required. It may be interesting to know that Lobos creek furnished San Francisco's first water supply, and that portions of the flume carrying the water along the bay shore to town may still be seen. In 1908 the United States Government installed near the mouth of the creek two filters having a combined capacity of 1,000,000 gal. per day, two pumping-engine units with boilers having a capacity of 3,000,000 gal. per 24 hours, and a 1,000,000-gal. concrete reservoir which receives the filtered water and from which the engines draw their supply. The increasing demands of the army post for water made extensions necessary, and in January 1912 a contract was let for two additional filter units, which this article will describe.

There are two filter units each including a 17-ft. diam. standard, American type, down-flow gravity filter, nominally rated at 1,300,000 gal. per 24 hours, corresponding to 2 gal. per square foot per minute. The filter tanks are constructed of select California redwood dressed to a net thickness of 2¾ inches. They are heavily hooped with 1-in.

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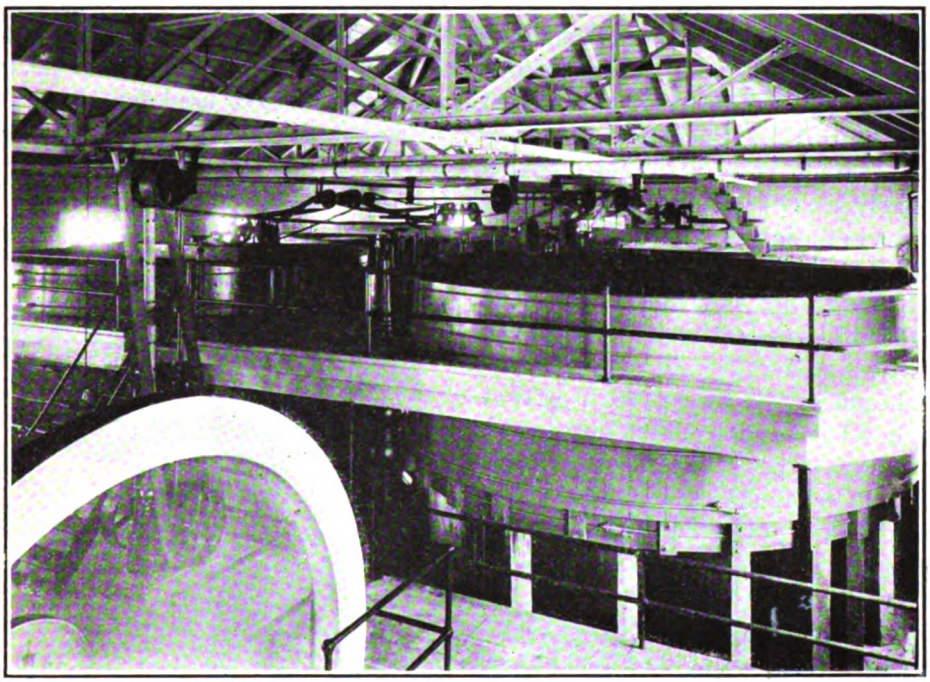
round iron. The durability of California redwood under alternately wet and dry conditions makes it preferable to, as well as cheaper than, steel, especially as alum is used in the water as a coagulant. The tanks are of double construction, the outer tank forming a collecting trough for wash water and also a distributing trough for the raw water. Each tank is supported on 8-in. thick concrete walls, spaced 24 in., at a height of 6 ft. above the filter-room floor, this being necessary to provide sufficient negative filtering head and also to accommodate piping connections. On the bottom of the tanks rests the collecting manifold system. This consists of three cast-iron headers, each with bottom outlet from which at 6-in. intervals 1¼-in. wrought-iron laterals branch. These laterals, as well as the headers, are drilled and tapped on top at intervals of 6 in. for ⅜-in. pipe, threaded to receive the strainers.

Each filter has a total of 850 strainers, corresponding to approximately four strainers per square foot of filtering area. This insures a very even distribution of water for both filtering and washing. The strainers are of brass, firmly riveted together and with slots around the entire circumference. The whole manifold system is imbedded in concrete up to the opening in the strainers. This makes the system permanent and also prevents the accumulation of dirt or bacteria below the strainer openings. With the type of sand-valve used, wash-water leaves the slots horizontally and parallel to the bottom, thus removing any accumulations which may have settled on the bottom. The filtering-bed in each filter has a horizontal area of 227 sq. ft.



INTERIOR PRESIDIO FILTER PLANT.

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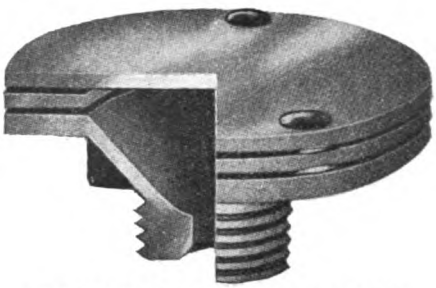
Directly over the strainers is placed a 5-in. layer of coarse gravel graded from ¾-in. to ¼-in. mesh, which aids the proper distribution of water flowing through the filter. Upon this layer of gravel is placed a 4-in. layer of gravel graded from ¼-in. to ⅛-in. mesh. The gravel is specially-selected, hard, durable, rounded pebbles. On the gravel is a layer of filtering sand 27 in. deep. The sand is a special filter-sand brought from Red Wing, Minnesota, having a pure silica content of 99%. The effective size of this sand is about 0.36 to 0.50 mm., and the uniformity coefficient about 1.5 to 1.75. Such sand with high silica content is very durable, lasting probably six or seven years before wear due to agitating and washing will require its renewal.

The agitating device consists of a number of swivel-valve bars suspended by swivel holders from a rotary reversible beam, driven by a system of spur and bevel gears and clutch-pulleys for reversing. The swivel-valve holders permit of revolving the valves in a vertical position, penetrating the filter-bed to a depth of 25 in., or upon reversing the rotary direction of agitation, the valves are automatically withdrawn by the action of the sand-bed upon them until their free ends rest upon the surface of the sand-bed. The automatic withdrawal of the sand bars eliminates the possibility of water following the bars and forming channels in the filter bed. The agitating apparatus is supported upon steel channel-beams extending across the tank, making a very firm support.

Water is delivered from the dam to the filters through a 12-in. cast-iron main, terminating with an influent regulator on each tank for maintaining a practically uniform head of water over the filter-bed. The valve is of the balanced type, this being preferable to the butterfly type which is liable to stick when full open or shut. The quantity of water passed through the filters is regulated by effluent controllers of the Venturi type, located on the line to the storage reservoirs. A simple loss-of-head device with electric-bell alarm notifies the attendant when the loss of head has reached a predetermined point where washing becomes necessary. The device consists of 5-in. float pipe, with float indicating-dial, electric bell, and battery. Two 200-gal. wooden tanks are used for mixing the coagulent solution. This flows by gravity into a small wooden tank in which the level is maintained constant by means of a ball float-valve. A hard-



AMERICAN STRAINER OR SAND VALVE.

rubber disc-valve with graduated wheel can be hand-set to feed the required amount of coagulating solution to the raw water.

The filters were built under a guarantee that each would have a capacity of 650,000 gal. per 24 hours, delivering filtered water, bright, clear, and practically free from suspended matter, turbidity, and color, and would furthermore show a bacteria reduction efficiency of 97%, provided that the raw water contained over 3300 bacteria per cubic centimetre, and to contain not more than 100 bacteria per cubic centimetre when the raw water contain less than 3300. The use of alum-coagulent

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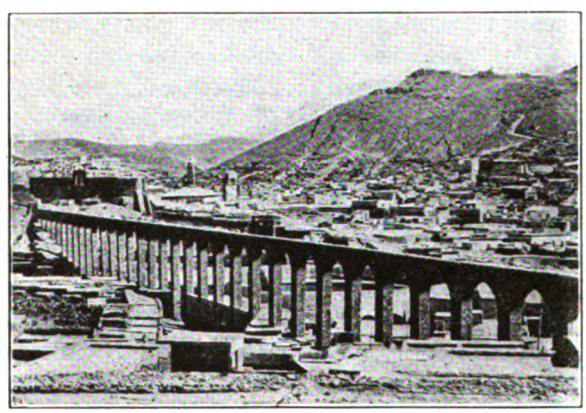
was to be limited to such an amount that its presence in the filtered water could not be detected. Under ordinary conditions, the filters easily exceed the capacity guarantee by 15%, and with 2000 bacteria per cubic centimetre in the raw water, showed only 20 in the filtered water, or a bacteriological efficiency of 99%, which is a very satisfactory performance.

An average of about one-half grain of alum is used per thousand gallons, which at a cost of $32 per ton for 17% commercial sulphate of alumina amounts to only 1.18 cents per 1000 gal. Such filters require very little attention and can be operated by any pumping-plant crew without additional attendants. The very low cost of obtaining clear pure water by filtration is well worth the careful consideration of the municipal engineer, especially in the small Sacramento and San Joaquin valley towns, where well water is often very hard and where an excellent supply of river water is available, requiring only filtration. The filters were constructed by C. F. Braun & Co., of San Francisco, the special filtering apparatus being supplied by the American Water Softener Co., of Philadelphia.



VIADUCT CARRYING FRESH-WATER SUPPLY TO CITY OF ZACATECAS, MEXICO.

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Sewage Disposal For Oil Camps and Pumping Stations

By C. P. BOWIE*

THE proper disposal of sewage from drilling-camps in the oil-fields and from pumping stations connected with the oil industry in California is a question as serious in arid districts as in low swampy land, where the pumping stations for the transportation of oil from the wells to the markets are often situated. During the hot summer months the population of the drilling camps can almost be considered transient, since it is usually the case that many of the men who work steadily during the winter seek the cooler climates of the coast regions when summer comes. These men are replaced by newcomers from all points of the compass, some of whom are apt to, and in fact often do, bring with them the germs of contagious diseases such as typhoid, at just the time of the year when the extreme heat renders all things favorable to the life and propagation of bacilli, and also greatly reduces the ability of the human body to resist the attacks of disease.

There is probably no one subject upon which sanitary engineers are more thoroughly in accord than the inherent vileness and danger, under the most favorable conditions, of the open privy closet and cesspool as ordinarily constructed. Fresh sewage, if not taken into the stomach, is not injurious to health, nor is its odor usually very offensive, but putrefying excreta and kitchen slops, especially during the hot weather, are not only most disgusting to sight and smell, but become breeding places for myriads of flies which carry on their feet disease germs to be deposited on the food eaten by workmen and their families. In the case of pumping stations, while there is less liability to the influx of germs due to the transient travel, the entire absence of noxious odors and the highest possible sanitary conditions are imperative, not only for the health of the operators and their families, but also in order to make competent men be contented to run the plants, which are usually situated in isolated districts.

To this end the septic tank shown in the accompanying drawing has been installed at all of the various pumping stations along the route of the Associated Pipe Line Company's main trunk lines at which the sewage could not be properly disposed of otherwise. This tank can be easily and cheaply constructed, and wherever used has given thorough satisfaction. It is 18 ft. long, 6 ft. wide, and from 8 to 12 ft. deep, and has ample capacity to take care of the sewage from five cottages, a pump and boiler-house, and one bunk-house, representing in all from 30 to 40 people, together with occasional repair and construction gangs which may number as many more persons. It is

*Engineer Associated Pipe Line Co., Wells-Fargo Building, San Francisco.

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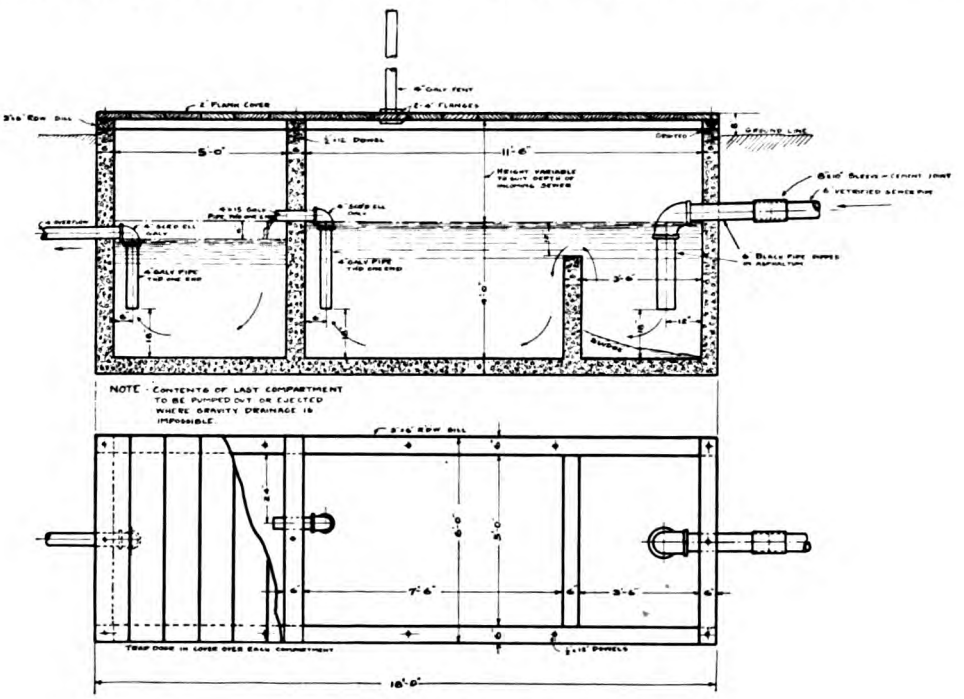
built of concrete with walls 6 in. thick, and is composed of two main compartments. In the larger compartment, shown on the right in the drawing, is a division wall extending to within 12 in. of the surface of the water, making virtually a third compartment about 3 ft. by 3 ft. 6 in. by 5 ft., which receives the incoming sewage. The object of this wall is to make sure that all sewage entering the tank will at some time be forced to rise to a point near the surface and not be swept along the bottom of the tank and out the overflow pipe by an unusually large influx of water. It is often the case that a considerable percentage of the sewage will lie dormant on the floor of the receiving tank for a number of hours before rising to the surface. This wall also tends to break up the direct current of the flow from the inlet to the outlet, and prevents suspended matter from leaving the main compartment before dissolution is complete, so that under normal conditions it is probable that practically all of the disintegration takes place in the larger compartment, and the effluent, which is discharged into the second compartment of the tank shown on the left in the drawing, contains little or no matter in suspension.



SEPTIC TANK, ASSOCIATED PIPE LINE CO.

Where the septic tank can be placed in such a position that drainage from the main compartment will discharge through the outlet to a cinder bed or sand filter, this last compartment is really not essential. It is, however, very necessary, in order to secure the proper gradient for flow from house fixtures, that the septic tank be placed at such a low point on the property that there can be no final drainage from it. In this case it is necessary to pump the effluent from the last compartment, or

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remove it with a steam ejector, thereby rapidly altering or violently disturbing the surface of the water in it. This agitation, were it to take place in the main compartment of the tank, would remove or destroy many of the bacteria under the surface scum with probably fatal results to the success of the dissolution process; quietude being essential to the life and propagation of the bacteria necessary to perform that function. Where it is necessary to resort to pumping, a float is arranged in this last compartment to indicate the position of the water, and the steam is turned into the ejector, or the pump started, before the water has risen so high that the surface in the main compartment is disturbed. For this reason, the last compartment should be made sufficiently large to amply accommodate the maximum flow in 24 hours from all possible sources, in which case pumping out once during that period can be made a routine of the day's work.

The top of the tank, which is placed about 8 in. above the surface of the ground to exclude run-off waters, is covered with 2 by 12-in. planks. In some tanks a vent pipe 4 in. diameter and 12 to 15 ft. high has been placed in the larger compartment to carry off the gases; in others this has been omitted. There being no perceptible odor about the tanks in either case, the vents are probably superfluous, especially when the houses are properly trapped—the gases generated daily from so small an amount of sewage being practically negligible.

Cementing Off Water in California Oilfields

By DORSEY HAGER*

IT is essential to the life of an oil well that water be excluded from the oil-sands. There are several methods employed in accomplishing this end, notably: (1) landing casing in a soft stratum of clay or shale by driving the same from above, (2) using seed-bags and packers, and (3) 'cementing off' the water-sands. The latter system is the newest and best, and may be described as follows: Portland cement and water are mixed to the consistency of light cream and the mixture pumped into the drill-hole in such a manner that it lies between the wall of the hole and the casing with which the hole is lined. The cement hardens and forms an impervious ring around the casing, thus effectively shutting off water from the oil formation below.

Technology of Process

When drilling has proceeded to the depth at which it is considered desirable to shut off water, the drilling tools are withdrawn from the hole. For example, assume that a drill-hole is lined with 8¼-in. casing, which has been carried below the water-sand *W* shown in Fig. 1. This string of casing is the one used in cementing off the water-sand and is called the 'water string.' As shown in Fig. 1, a hard 'shell' or sandstone bed was chosen as a nest for the cement. The water-sand *W* lies 75 ft. above the oil-sand. A string of

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3-in. tubing is now let down inside the 8¼-in. casing, within 10 or 15 ft. of the bottom of the hole. At the top of the casing the tubing passes through a tightly packed casing-head. When the tubing is in the hole, both casing and tubing are raised together a distance of 5 ft., which leaves the casing 5 ft.

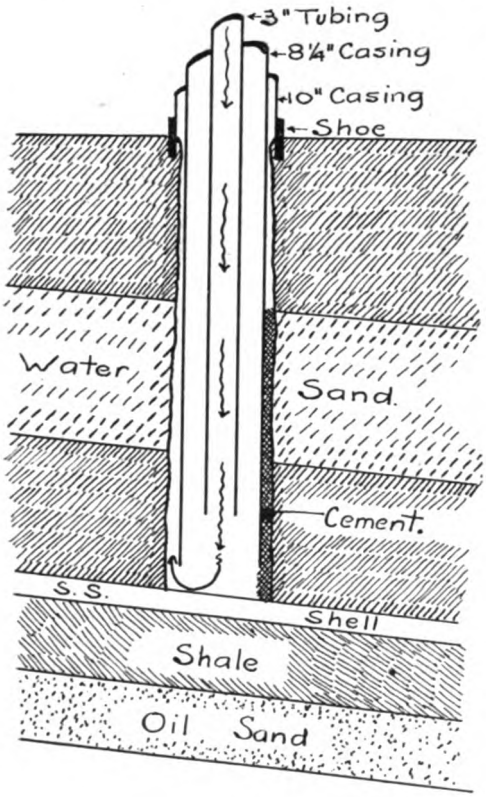

FIG. 1.

above the 'shell' bed, and the tubing 15 or 20 ft. from the bottom. It is necessary to force the cement through the tubing and around the outside of the casing. Before this can be done it is essential to have good circulation, so that the cement will be carried around the outside of the casing. The drill-hole contains drill cuttings, mud, etc., which must be washed out. This is done by pumping clear water through the tubing under a pressure of 150 to 250 lb. per square inch. The column of water around the casing is set in motion and the hole is soon washed clean. Everything is now ready for cementing.

MIXING THE CEMENT

The cement is mixed in a large rectangular box 8 by 16 by 12 ft., which holds five or six tons of cement. At one end of the box is a suction pipe guarded by a screen. This suction is connected to a large duplex pump of the 'Gumbo Buster' or Blake type, 10 by 5¾ by 12 in., having 8 valves and capable of pressures up to 400 lb. per square inch. The suction is 6-in. diamter and the discharge is bushed to 3 in. to fit the 3-in. tubing in the well.

Fig. 2 shows the arrangement for mixing cement. *B* is the mixing-box, *P* the pump, *T* a 50-bbl. tank for water, and *S* the tubing. The line *s* is the suction from pump to mixing-box; *w* is the line from the tank to pump and enters *s* at *t*; *d* is the discharge from pump to tubing, and *h* is a tee at which a 2-in. wire-wound hose is attached so that water may be pumped through the hose to the mixing-box, when gate No. 4 is opened and No. 3 is closed. The bottom of the mixing-box is covered with 3 or 4 in. of water. The cement is then dumped in and water is pumped into the box through the hose *H*. The cement, in sacks of 100 lb. each, is arranged on one side of the box. Seven or eight men are told off to dump cement, while an equal number are provided with hoes for mixing it. The men who handle the cement rip open the sacks and empty them into the box, while those on the opposite side use their hoes for mixing. During this mixing process the suction pipe *s* is kept closed by gate No. 1, and water from tank *T* is played into the box

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through *H*. A thorough mixing of the water and cement requires 15 or 20 minutes. When the mixture reaches the proper consistency, that of a light cream, the water is cut off and gates No. 1 and No. 3 opened. The cement mixture is now pumped into the well through the 3-in. tubing. In less than 15 minutes the box is empty, and all the cement is in the hole.

The discharge line from pump to tubing is now disconnected and the casing lowered on the 'shell' bed. The tubing is next pulled from the well and the hole bailed out while the cement is soft. When most of the soft cement inside the casing has been cleaned out, the well lies idle for two to three weeks to give the cement around the outside of the casing time to set. At the end of that time drilling is continued. Generally 10 or 15 ft. of cement remains in the bottom of the casing and must be drilling through, which is a simple process. Cementing is a very simple operation, but unless proper precautions are taken the results may be very unsatisfactory. Oil in the hole nullifies what might otherwise have been good results. Oil lengthens the time of set, decreases the tensile and compressive strength of the cement, and weakens its resistance to high water-pressures. So far as I know, no maximum allowance has been determined for the percentage of oil that can remain in the hole without harm to the cement, though one or two per cent of oil should not cause serious trouble. If gas shows in the drill-hole it may be very difficult to get good results, as the continuous working of the gas through the cement keeps it in a state of agitation which prevents setting. Extremely high water-pressures, 500 and 600 lb. per sq. in., also adversely affect cement, which, if at all porous, allows the water to wear channels through it. Cementing an oil well, although a simple process, requires care and study.

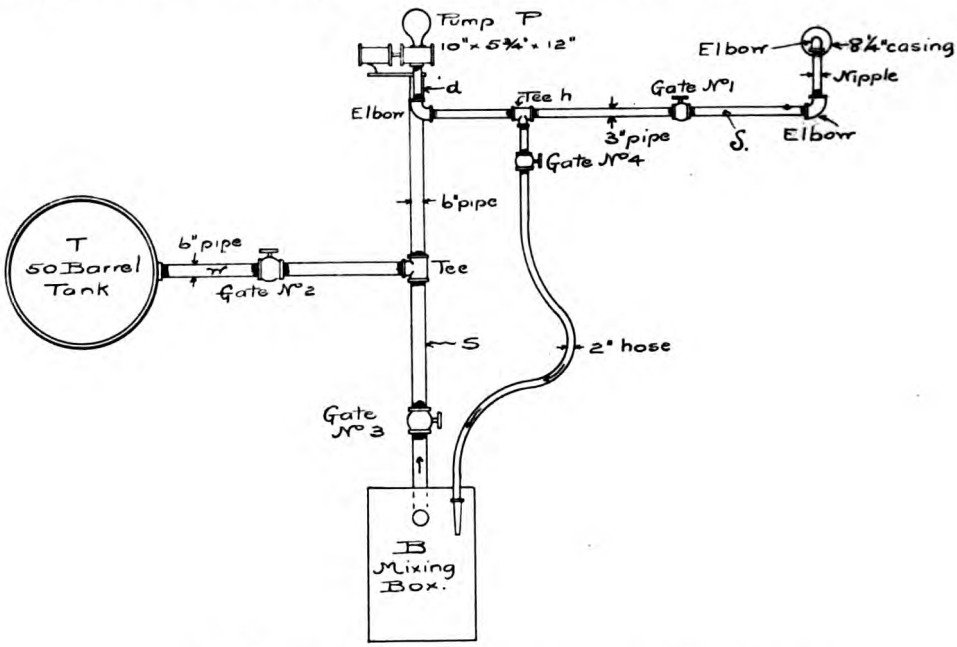

FIG. 2. DIAGRAMMATIC ARRANGEMENT FOR MIXING CEMENT.

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Elements of Efficient Steam Generation

By A. BEMENT*

This matter is a complicated and involved one, making its treatment difficult, unless it be separated into its different elements. Therefore each of the items are considered in a distinct chapter devoted to the subject, and to that one only. Most of the steam used on the Pacific Coast is generated by oil fuel, to which the discussion regarding coal does not apply; the other features, however, have the same significance with oil as they do with coal.

Efficiency of the Boiler

The purpose of the steam boiler is to extract the heat from the hot gases which flow from the furnace in contact with it. Thus we have the heat generated in the furnace and carried by the gases of combustion for delivery to the boiler. The heat-absorbing capacity, or in other words, efficiency of various boilers, differs according to their design and arrangement of heating surface. The principal elements governing efficiency are:

1. Form and design of gas passages, allowing the hot gases to come in contact with a greater or less amount of heating surface.

2. Time in which the heated gases are in contact with the heating surface.

3. Velocity of the hot gases in their flow through, or in contact with, the heating surface.

Thus with a water-tube boiler, for example, if it is so baffled that the gases pass over its surface but once, heat abstraction will be relatively small. But if so baffled that the gases flow across, or lengthwise of the tubes three or four times heat abstraction will be relatively large. This principle is illustrated by the cylindrical boiler. If it be a plain cylinder with gases flowing under it, thence to the chimney, heat abstraction is small. But if the same boiler be filled with tubes, through which the hot gas passes after it has left the under side of the boiler, heat abstraction is large. It has been said that "the boiler is a definite arrangement of heating surfaces, plus any fixed arrangement of gas-baffles, which may be in use for the purpose of directing the course of the heated gases over the heating surfaces." There is, however, a point beyond which baffling may not be carried; it is when the increased resistance so reduces capacity as to limit the gain from efficiency and capacity.

Furnace Efficiency

Furnace performance, to be efficient, requires not only that all of the fuel be burned—in other words that combustion be complete—but that the heat be generated at a temperature making it useful to the boiler. This implies a high temperature. For example, it would be possible to have complete combustion with a very large excess of air. The result would be a correspond-

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ingly low initial temperature, for which reason the heat would not flow into the boiler as well as if the temperature had been high. It is very necessary, therefore, to have complete combustion with a minimum air supply, in order that not only will all the heat be generated, but at such a temperature that it will flow readily into the boiler. Thus it is evident that temperature of combustion is an important factor. This temperature has two phases which makes its direct measurement by an instrument a matter of some difficulty. For example, if the fuel is burned in a brick-enclosed furnace before the products of combustion come in contact with the boiler, measurement with an instrument will give a much higher reading than it would in another case having, according to gas analysis, exactly the same combustion, but where the boiler is exposed directly to the fire, because in the former case, the full temperature of combustion is realized in the furnace. This condition makes no difference in efficiency, however, as what may be called the theoretical temperature is the same in each case. The difference is that in one case heat escapes from the furnace sooner than in the other.

Importance of Capacity

In considering cost of producing steam, the items of fuel and labor are usually given much prominence. While fixed charges are not so often taken into consideration, yet this may be, and usually is, a considerable portion of the cost of steam-making. The investment in ground, buildings, boilers, and fuel-handling equipment is a large portion of the cost of the power-plant. If this portion of the plant is worked at a high capacity, it results in a correspondingly lower fixed charge per unit of output. For illustration, if it be planned to work boilers at a rate of 1 hp. output for each 5 sq. ft. of heating surface, instead of 10 sq. ft., the effect would be practically to cut the fixed charges in two. Therefore, it may be economy to purchase only half as many boilers, etc., as might at first consideration seem desirable, and in this way have a low fixed charge. It is of course true that efficiency in steam generation falls off with increase of capacity. This, however, may not be enough to cause a loss equal to the gain in fixed charge. In fact, it seldom is. The price of fuel is the usual controlling factor. If high, large investment in boiler plant and correspondingly higher fixed charge is justified, for the sake of high heat efficiency, but if fuel is cheap, then a minimum fixed charge is essential. If it be proposed to work a boiler at twice the usual capacity, the grate surface must be made twice as large for the same draught, or draught and grate area must be correspondingly increased.

The Use of Economizers

An economizer placed in series with the boiler for the purpose of extracting a further quantity of heat from the gases after leaving the boiler, is a device which has been extensively used in Europe, but has had a limited application in the United States. Justification for its use is, however, dependent principally upon the price of fuel. If fuel is cheap, it will not pay to use the device, but if expensive, the economizer may be justified because the fixed charges and maintenance of the economizer are comparatively large items; especially so, when it is considered that of the total heat in the coal, the boiler may absorb 60 or 70% and the economizer only 10%. The cost of boiler and economizer is not in

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the same proportion, the economizer being comparatively more expensive. Thus it is necessary to figure each application with much care.

Draught and Chimney Height

In burning solid fuel, a strong draught is always to be preferred because it produces a better condition of combustion, the air-supply and its mixture with the gases of the fuel being more effective. It is, however, necessary to proportion the grate surface to the draught; thus, if the draught is very strong, the grate surface should be small. If the draught is mild, the grate surface should be large. It is usually an error in hand-firing to employ very large grates with strong draught, because the fuel-burning capacity is usually beyond the capacity of the fireman to properly stoke the fire. Therefore, in hand-firing it is important to proportion the grate to the ability of the fireman. Another important reason for a strong draught is that if especially efficient boilers are used, it is necessary to have sufficient power to draw the gases through the heating surface, so that capacity may be obtained. Formerly the requirements of air-supply through the fuel-bed have governed in design. The resistance, through the boiler, however, may become and is, in fact, a factor of first importance in those cases where very efficient boilers are employed. This is especially true where oil fuel is employed, because very little draught is required in the furnace. Thus there are possibilities of great economy by the employment of highly efficient boilers in cases where oil fuel is to be employed, because the power of the draught may practically all be expended in moving gases through the boiler.

Loss in Smoke

The loss due to the production of smoke, or, in other words, the inability to secure complete combustion, is usually serious, especially so with high volatile coal, or with high volatile oil; not that the carbon which gives color to the gases is in itself a serious item, although it is one of importance, but that the condition which makes possible the escape of free carbon in this form is accompanied by other losses much more serious, in the form especially of hydrocarbon compounds which are difficult to detect by analysis, as well as that of carbon-monoxide.

Manipulation of Fires

There are good and bad boilers; efficient and inefficient furnaces; and other features of the fixed apparatus of varying quality. None of these, however, are factors of such importance in economical steam generation as the manipulation of the fire. A good fire is a thing of first importance, and generally the best means of obtaining good combustion is through proper manipulation of the fire, which can be determined by means of evidence accorded by an analysis of the combustion gases. The important features of good combustion are completeness, uniformity, and minimum air-supply. First uniformity should be attained, after which air-supply can be adjusted to that point, below which it is not advisable to reduce it further, on account of danger of incomplete combustion.

Clean Boilers

An accumulation of scale in the interior of boilers is often credited with the ability to cause the waste of an excessive amount of heat. While it is true that thick scale does seriously

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retard the transmission of heat, and that scale of different characters has varying retarding influence. it is probable that these losses are generally overestimated. This does not mean, however, that it is undesirable to keep boilers clean, because the better heat-transmission quality and the reduction in maintenance due to prevention of burning tubes and plates are each of sufficient importance to justify frequent and thorough cleaning of boilers internally and externally.

Quality and Ash Content of Coal

The quality or value of coal is principally dependent on three things: heating power, ash, and moisture content. The heating power will range from about 15,800 b.t.u. for the best coal down to 13,500 b.t.u. per pound of pure coal (ash and moisture-free coal), a difference of only 17%. No one locality, however, has access to coal of such large range in b.t.u. quality. The difference in heating power of coal accessible to a locality is not often greater than 5%; therefore it is not a matter of large significance. Ash, however, is a factor of much importance, as it not only displaces an equal amount of the fuel, thus decreasing heating power, but also interferes with combustion to such an extent that the full heating power even of the percentage of coal present is not realized. This may be so serious that in some cases as much as one-half of the heat contained is lost. The reason is that the ash in the fire, either in the form of clinkers or otherwise, obstructs the air-supply so that combustion is not complete. At the same time, and for the same reason, the coal-burning capacity is reduced, with the result that the volume of combustion gases is smaller, while at the same time the natural leakage of air into the furnace remains the same. The relative excess of air, therefore, is much greater. Thus the heat-loss due to these conditions consists both of incomplete combustion and excess air.

Size of Coal and Thickness of Fire

The diameter of the pieces, or, in other words, the size of the coal which may be employed, is usually a factor of considerable importance affecting the efficiency of combustion. If the pieces are too large, there is generally a serious excess of air flowing through the fuel-bed; if the pieces are too small there is a tendency for the fuel to mat together, excluding a proper air-supply, with a result that smoke, incomplete combustion, and a consequent loss ensue. Thus, with stoker-firing especially, it is desirable to regulate the thickness of the fuel-bed in proportion to the size of the fuel. If large, a thicker fire should be employed; if small, a thinner fire would be more desirable. With hand-firing, however, the natural condition may be to a considerable extent corrected because the fireman may manipulate the fuel-bed in a manner that will overcome disadvantages due to variation of size. Whatever size of coal may be employed, uniformity is always desirable. The pieces should be as nearly the same size as possible. Fuel of uniform size, however, is something that is not always obtainable; so it is more often necessary to adjust the conditions by the manipulation of the fuel, than to obtain coal which may be suited to the wishes of the user.

Moisture in Coal

All coal carries a certain amount of moisture, which not only causes a lower temperature of combustion in the fur-

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nace, but its escape through the chimney carries away a certain amount of heat which is lost. It is true, of course, that when the water is expelled from the fuel in the form of steam in the hot furnace, it may be dissociated, and the hydrogen may then be burned by combining again with oxygen. This is not a heat-producing process, because the energy developed in the combustion of the hydrogen is the same as that required for the dissociation of the hydrogen and oxygen coming from the coal in the form of moisture. Thus the presence of moisture in coal always entails a loss of heat; first, by limiting the initial temperature of combustion, for which reason less heat flows into the boiler; and, second, because heat is wasted in the chimney. There are cases, however, when it is found that putting water on coal is beneficial, resulting in a higher efficiency being obtained in steam generation than if the water had not been used. This fact has led to confusion and misunderstanding regarding the advisability of wetting coal. The reason better results are obtained when coal is wetted is due to the fact that a more uniform fuel bed is produced and leakage prevented.

Moisture in Compressed Air

By JACOB H. WALLACE*

ALL air is compressed air. Atmospheric air presses on the earth's surface to a degree varying with the altitude and with local meteorological conditions. In the arts and sciences air is used at both greater and less pressure than that of the atmosphere. In the use of air at any pressure, more or less moisture is always present which may or may not be desirable or permissible. It is the object of this article to present a chart by means of which the carrying capacity for moisture can be determined throughout the changes imposed during the processes to which air is subjected to prepare it for use. Air is a mixture of gases. Nitrogen, oxygen, etc., are usually present in uniform proportions. These gases constitute pure dry air. Water vapor, moisture, or steam are present to some degree, depending upon evaporative conditions. According to Dalton's law for mixed gases, when the temperatures are the same the product of the volume and pressure of the mixture is equal to the sum of the products of the volume and pressure of each gas taken separately. Let P_m represent the pressure of the mixture, and V_m its volume; P_a the pressure of the pure dry air, V_a its volume; P_s the pressure of the steam and V_s its volume; then

$$P_m V_m = P_a V_a + P_s V_s$$

If the volumes as well as the temperatures of each gas were the same and both forced into one volume, to produce one volume of mixture at the same temperature, the resulting relation of pressure would be expressed by the equation

$$P_m = P_a + P_s$$

The pressure of the mixture is the sum of the pressure of the pure dry air and

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the pressure of the steam. This relation is exactly true for a mixture of pure dry air and saturated steam. One cubic foot of saturated steam will saturate a cubic foot of space regardless of the presence of pure dry air at any pressure, provided the temperatures are the same. The weight of the moisture in a given volume of saturated air depends upon the pressure of the saturated steam only. These statements may be corroborated by comparing tables for saturated steam and for saturated air. The same weight is given for the same temperatures, therefore in order to ascertain the moisture in a cubic foot of saturated air it is only necessary to determine the temperature and refer to any table, with sufficient range, giving the properties of saturated steam.

In the manufacture and use of compressed air, the temperature of the air and the steam are the same and the volume utilized is available for saturation by steam. As a matter of fact, during adiabatic compression, the air attains a capacity for moisture which is never filled in practice. The moisture in saturated air at the beginning of compression superheats during compression. The moisture in the atmosphere when the humidity is less than 100% is superheated steam. If water were maintained in contact with and at the same temperature as the air during compression, the temperature-volume curve would not follow even closely the curve $TV^{0.41} = K$ nor be a continuous curve, because the boiling point of the water would be reached. This point occurs when the pressure of the steam corresponding to its temperature exceeds the pressure of the mixture. But, as previously noted, these conditions hardly ever occur. The curve of compression for water jacketed compressors falls above or below the adiabatic curve, depending upon the efficiency of cooling. The weight of saturated steam at a given temperature varies directly with the volume, consequently the temperature-volume changes of the air will be accompanied by definite changes in the weight of the steam necessary for saturation. The temperature-volume and weight changes, together with their relations, are shown graphically on the accompanying chart. The temperature range is from 30° below to 430° above zero Fahrenheit. It may be noted in passing, that the range in pressure for the steam alone corresponding to these temperatures is from less than 1 lb. to 350 lb. absolute pressure. The volume range is from zero to 150 cu. ft. The adiabatic lines of constant heat, such as occur for compression or expansion without cooling or heating during the process, were calculated for pure dry air. The lines of constant pressure were drawn through absolute zero of temperature and volume.

By way of explanation, let pure dry air be compressed adiabatically, then cooled by constant pressure to the initial temperature, then expanded adiabatically to the initial pressure, and finally heated to the initial temperature at constant pressure. Let the range be 15 to 50 lb. absolute pressure and the initial temperature 60° and the volume 100 cubic feet.

For an isothermal change

$$P_1V_1 = P_2V_2$$

consequently

$$15 \times 100 = 50 \times V_2$$

whence

$$V_2 = 30 \text{ cu. ft.}$$

This is the minimum volume attained. Now the adiabatic line which passes through the point on the diagram.

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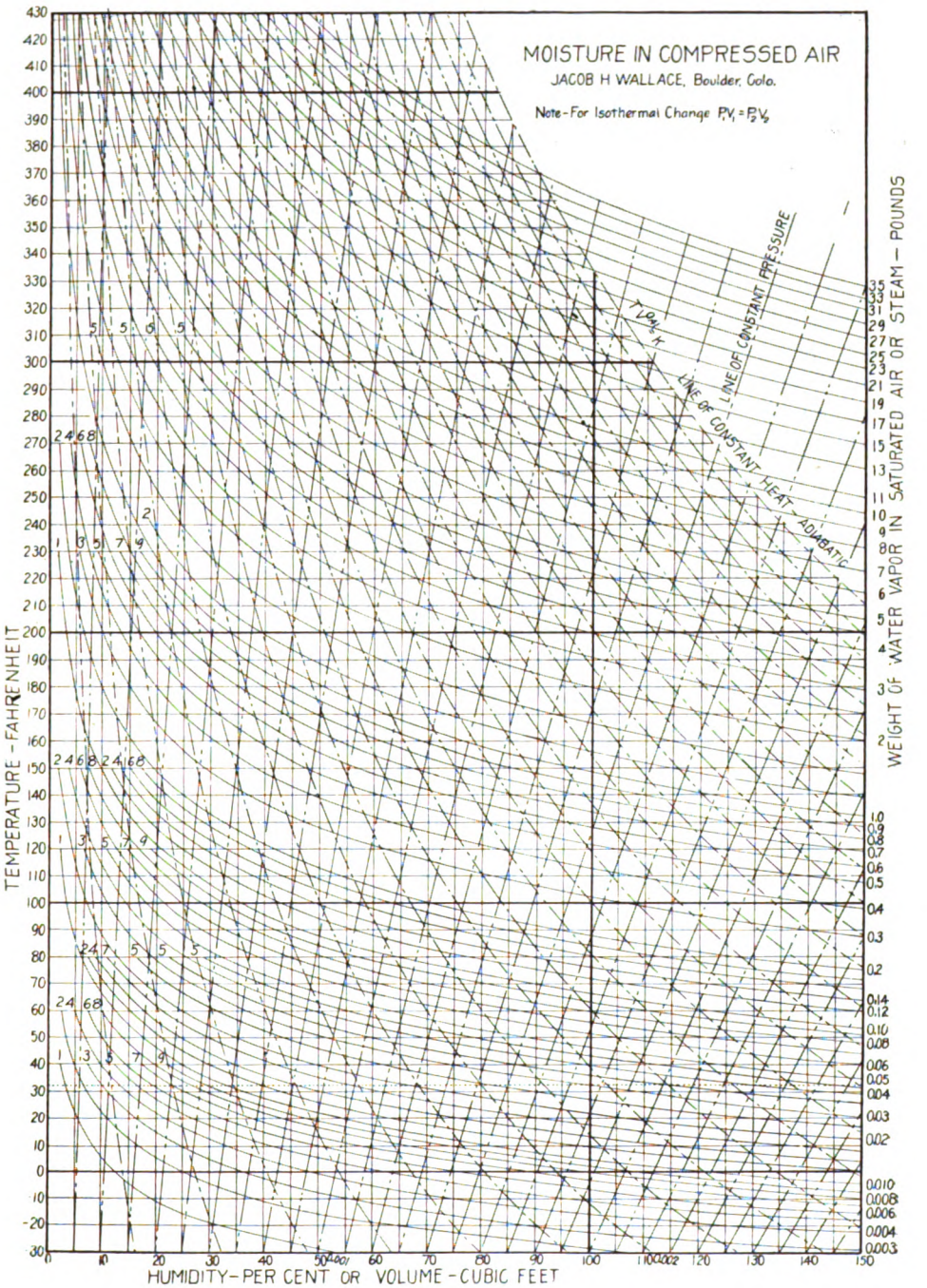

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'temperature 60, volume 100,' will meet the constant pressure line which passes through the point, 'temperature 60, volume 30,' at a point, 'temperature 285, volume 42.' Such a change would occur in a compressed-air system working continuously.

An adiabatic expansion from 'temperature 60, volume 30,' would meet a line of constant pressure which passes through the initial point, 'temperature 60, volume 100.' This intersection is at a low temperature which the diagram has not been extended to show. As a matter of fact the temperature below 32°, shown by the dotted line, is seldom passed during enclosed expansions, owing to the fact that moisture is usually precipitated and frozen, thus interfering with or stopping the practical operation of the process. The partially expanded air is thrown bodily into the atmosphere, where its low temperature can do no harm, or re-heated for a successive expansion. During the cycle of temperature-volume change just outlined, the moisture-carrying capacity of the air was a maximum at the maximum temperature and a minimum at the minimum temperature. At conditions of the same temperature the capacity to carry moisture was proportional to the volume. At the initial 'temperature 60 and volume 100,' the capacity for moisture was 0.08 lb. At 'temperature 285, volume 42,' the capacity for moisture was 3 lb. At 'temperature 60 and volume 30' the capacity for moisture was 0.024 lb. Owing to the fact that the weight of moisture in 100 cu. ft. of air is directly proportional to the humidity and also directly proportional to the volume, the scale used for volumes is available also for humidities. Advantage has been taken of these facts in preparing the chart.

In order to determine the weight of moisture in 100 cu. ft. of air for any humidity and temperature, apply the humidity on the humidity scale, the temperature on the temperature scale, and read the weight on the weight scale. Thus, if the humidity is 50% and the temperature 40, the weight of the moisture in 100 cu. yd. is 0.02 pounds.

In order to determine the humidity when the temperature, volume, and weight are known, divide the humidity-reading for the intersection of weight and temperature lines by the volume of the air and multiply by 100. Thus, if the temperature is 50, the volume 90, and the weight of moisture 0.03 lb., the humidity-reading, for the intersection of weight line 0.03 and the temperature 50, is 52, hence, the humidity is 57.7%. An inspection of the chart readily reveals two facts in regard to humidity and the isothermal compression of 100 cu. ft. of air. The volume to which 100 cu. ft. of air can be compressed isothermally without precipitation is numerically equal to the humidity. The maximum humidity which air can have when compressing 100 cu. ft. isothermally without precipitation is numerically equal to the volume after compression. In order to determine the weight of moisture precipitated during isothermal compression when humidity, temperature, initial, and final pressures are known proceed as follows:

Let the humidity be 70%, the initial and final pressures 14 and 70 lb., respectively. By the isothermal equation the initial volume of 100 cu. ft. will be compressed to 20 cu. ft. The weight of moisture in 100 cu. ft. humidity 70%, temperature 70, is 0.08 lb. The moisture in 20 cu. ft. of saturated air at temperature 70, is 0.0226 lb. The difference between 0.08 and 0.0226 is 0.0574 lb., the weight pre-

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cipitated. In order to determine the minimum temperatures, and their corresponding volumes for no precipitation in the stage adiabatic expansion of 10 cu. ft. of saturated air, any pressure, temperature 60, preheated to temperature 200 before each expansion, proceed as follows. These conditions forbid passing below the weight line 0.008, which passes through temperature 60, volume 10. Preheating before the first expansion will be accomplished along a constant-pressure line to a temperature of 200, volume 13. Expansion along an adiabatic line will reach the temperature 30, volume 28. Re-heating along a constant-pressure line will reach the temperature 200, volume 37.5. Expansion along an adiabatic line will reach the temperature 3, volume 88. In order to determine the temperature of saturation, or dewpoint when the humidity and temperature are given, find the intersection of the weight-line for the given humidity and the constant-pressure line which passes through the given temperature and volume 100 and read the required temperature on the temperature scale. Let the humidity be 35% and the temperature 88. The weight-line as found on the chart is 0.07 lb. The constant-pressure line through temperature 88, volume 100, meets the weight-line 0.07 at temperature 57, which is the temperature sought.

Owing to the fact that humidity and temperature, as reported by the Weather Bureau, furnish a basis for determining the weight of moisture in 100 cu. ft. of atmosphere, regardless of a change in volume due to a change in temperature, a correction must be applied to one of two reports in order to make them comparable. A volume of 100 cu. ft. of air will not occupy 100 cu. ft. at any other temperature when the pressure is the same. If the Weather Bureau reports a humidity of 15% and temperature 70 for 6 p.m., and a humidity of 42.5% and temperature of 41 for 6 a.m., according to the chart the amount of moisture at 6 p.m. is 0.017 lb. in 100 cu. ft., and at 6 a.m. 0.0175 lb. in 100 cu. ft. This shows an increase in moisture of 0.0005 lb., during the night. However, the 100 cu. ft. of atmosphere at 6 p.m. has reduced in volume during the night to 95 cu. ft., as determined from the chart by following a constant-pressure line from temperature 70, volume 100, to temperature 41, and reading the volume on the volume scale. In order to reduce to comparable terms (weights) by means of the chart, let the report for 6 a.m. be adjusted as follows. Instead of following the humidity line 42.5 to temperature 41, pass to temperature 70, then follow a constant-pressure line to temperature 41. This terminates, in this case, on the weight line 0.017, which shows that no change in moisture had taken place during the night. Let air at temperature 30 and humidity 90% be brought into a building and heated to temperature 70. What is the humidity inside the building? Follow the weight-line (0.035) which passes through temperature 30, and humidity 90, to temperature 70; then pass down a constant-pressure line to temperature 30; then pass down a vertical line to the required humidity—20%. This result includes correction for change in volume due to change in temperature. In the above problem, how much water must be added to 100 cu. ft. of air to obtain a humidity of 62%? The weight-line for temperature 70 and humidity 20% is 0.0325 lb. The weight-line for temperature 70 and humidity 62% is 0.07 lb. The difference between 0.0325 and 0.07 = 0.0375, the required weight.

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Lost Hills and Belridge Oilfields of California

By R. P. McLAUGHLIN *

DEVELOPMENTS of the past two years in the territory between Coalinga and McKittrick, particularly in the region of the Lost Hills and Belridge, have furnished several surprises. As no official map has been published since U. S. Geological Survey Bulletin 406 was issued, it may be of interest to present one showing the position of small ranges of hills and indicating in a general way developments by wells drilled. Geologic exposures are very rare, the ground being covered with loose gravel and sand. The topographic relief of the district is so slight, outside of the Temblor range, that the accompanying map gives a better idea than most contour maps. Elevation of the hills above the surrounding plain is seldom over 100 ft. and frequently less. Points at which oil has been developed in paying quantities are indicated approximately on the map by black spots, while points where wells have reached any considerable depth without developing oil are shown by circles. Such other wells as are not shown on the map are either of slight depth or within the groups of closely drilled wells.

Discovery of oil in paying quantities was first made in Sec. 30, T. 26 S., R. 21 E., in the summer of 1910 by Martin and Dudley, and is one of the very few oil finds made in California under the spectacular and romantic circumstances frequently attending discoveries in precious-metal prospecting. Usually wells are sunk in territory where most operators in the locality consider that chances of bringing in a well are fair, enough money is collected to sink a well with ordinary tools, and no secrecy is made of the fact that operations are under way. In this case, however, the territory was but little known and frequently condemned as being either worthless, or too deep for present conditions. There were almost no surface indications of oil. The region was practically an uninhabited desert, seldom visited except by a few cattlemen. One man, Orlando Barton, clung to the theory that it was valuable oil land, and finally induced the discoverers to drill.

Under these most unfavorable conditions a portable rig, such as is seldom used in drilling a thousand feet, was started where most observers considered that the depth to oil, if indeed any was present at all, would be three to four thousand feet. The utmost secrecy and economy were maintained, as is shown by the fact that the usual fuel oil was not hauled to the place, steam being made by burning sagebrush. Fortune favored this first undertaking. Gas was struck at less than 300 ft., which from then on was used to fire the boilers, and only a single string of casing was necessary to shut off the water and produce oil, which was struck at 472 ft. Subsequent operations by well-financed concerns in the

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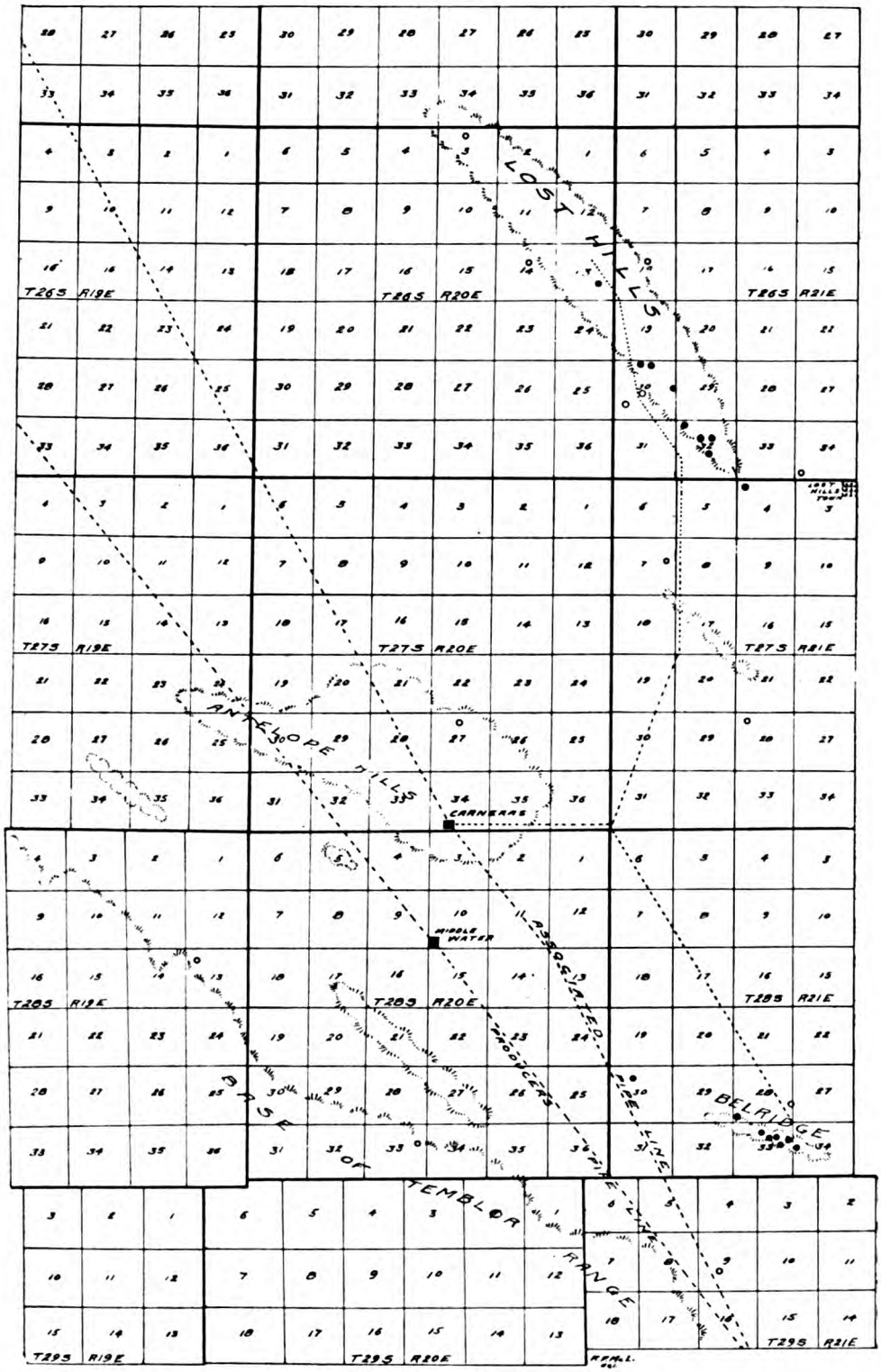

MAP OF BELRIDGE AND LOST HILLS OILFIELDS.

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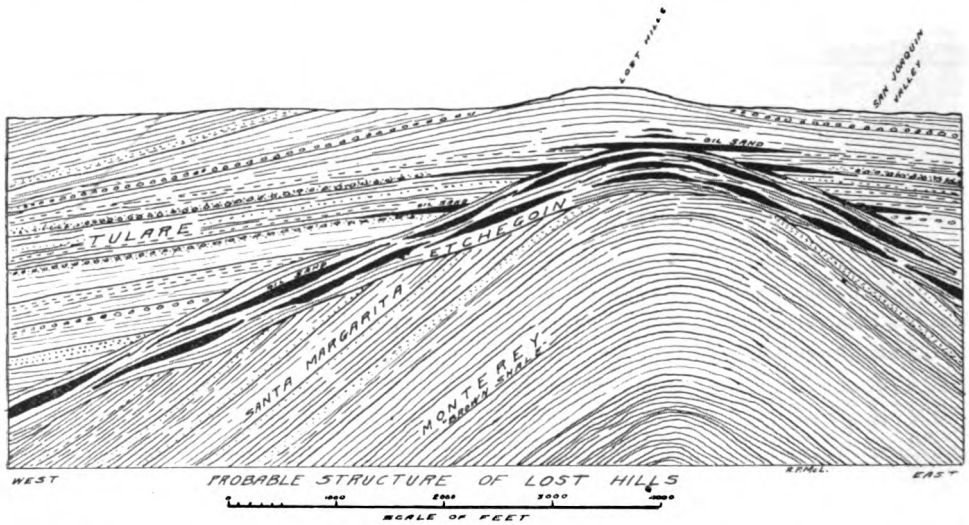
neighborhood have required considerable money for fuel-oil and many costly experiments trying to shut off water, not all of which were successful. When the discovery became known, the district was the scene of considerable excitement. The expectation was that the oil measures would dip away gently from the hills, with a similar slope to that of the ground surface. Many portable rigs were erected and drilling commenced within a mile or two from the hills. A large proportion of these operations have been unsuccessful.

Operations in the Belridge district began nearly a year later, and oil is being produced from a number of wells less than 1000 ft. deep. This territory had seldom been considered valuable, but there was a slight outcrop of oil-bearing sand, known to only a few persons. As much of the adjoining land was patented, and in large holdings, no considerable rush ensued. An explanation of the surprise at oil lying at such shallow depth in the Lost Hills is afforded by proof that it occurs in a much later formation than at Coalinga, of which the district was considered an extension. The oil-bearing formation is of the same age as that in the McKittrick and Midway fields. The structure of the Lost Hills is doubtless anticlinal, but, contrary to occurrences in other nearby fields, the dip of the oil formation does not closely follow that of the surface of the ground nor the exposed strata. The accompanying sketch shows the geological relation of underground formations as indicated by wells drilled and surface observations to the westward. The structure at the Belridge district is probably similar to that at the Lost Hills, an anticline extending from Sec. 30 to 34, T. 28 S., R. 21 E., the ends being not yet definitely proved. There is a possibility that other anticlines bearing oil may exist in the region, some indicated by the ranges of hills and possibly some have no surface indications whatever. It is fairly certain that some of the hills shown on the map will not be productive of oil. The general region is apt to attract interest for some time to come, and a considerable increase over the present production is to be expected.



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The Engineering Digest

Alaska Railway Routes From Pacific Seaboard to Fairbanks*

By ALFRED H. BROOKS

THERE are a number of possible routes of approach for railways from the Pacific to central Alaska. Those which are most important fall into three general zones: (1) from Lynn canal by way of Chilkat, Alsek, White, and Tanana river basins; (2) by way of the Copper and Tanana basins; (3) by way of Kenai peninsula and Susitna and Tanana river basins. Within these general zones there are several alternate routes. There are other possible railway routes to the interior of Alaska which will be briefly described, though they do not pertain to the main subject of this article. All these routes will be described in geographic order from south to north.

Generalized profiles have been made of the principal routes. These profiles are based on the best information obtainable and indicate approximately distances and grades. It cannot be too strongly emphasized that the surveys of these routes are far from complete and that the data here presented can be of service to the locating engineer only in suggesting the general choice of routes. Accurate distances and grades can be determined only by detailed location surveys.

White Pass Route

The White Pass & Yukon railway, a narrow-gauge road, has its coastal terminal at Skagway, which is at the head of Lynn canal, about a 1000-mile journey by inland water from Seattle, and is well provided with wharves. The railway ascends Skagway river for about 12 miles, then, leaving it, crosses White pass at the international boundary, 20 miles from tidewater, at an altitude of about 2880 ft. In this distance there is a grade of a little less than 4% for a distance of some 15 miles. From the pass the railway has a down grade for 90 miles to its terminal at White Horse (elevation 2090 ft.), on Lewis river. The steamboat trip down Lewis and Yukon rivers to Dawson (460 miles) takes about two days; the return journey about four. The steamboat route from Dawson to Fairbanks is about 1000 miles long. All but about 20 miles of this railway lies in Canadian territory. The White Pass railway could be extended to Lake Kluane by building about 120 miles. This route would lead over easy grades. At Lake Kluane it would intersect the route to be described from Lynn canal to the Tanana. The distance from Lake Kluane to the White river copper deposits is about 120 miles.

Route from Pyramid Harbor, Southeastern Alaska, to Fairbanks, by way of White and Tanana Valleys.

The Pyramid harbor-Tanana valley route leaves tidewater at Pyramid harbor, which is about 1000 miles by inland water route from Seattle. Pyramid harbor affords good water and shelter and presents no difficulties in wharf construction. The route extends up Chilkat river and crosses the international boundary about 6 miles from tidewater. Several passes, about 3200 ft. in height, lead from the Chilkat basin to the Alsek basin. Once over this divide the railroad route follows a series of natural depressions and valleys all the way to Fairbanks. These depressions, which parallel

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the inland front of the St. Elias range, afford an admirable route for a railway. One route would be by Dalton port and thence due west to Kaskawulsh river and up that stream to a low divide that separates it from Slims river, which flows into Lake Kluane. An alternate route would go farther northeast, by Lake Dezadeash and on to Lake Kluane. The route would continue to the west along the south side of Lake Kluane and beyond, crossing Donjek river in an almost straight course to the canyon of White river, where a suitable place for a bridge could be found. From this place the route would cross the broad flat that separates the White and Tanana basins. The rest of the route would be down the Tanana valley, probably on the north side.

Yakutat Bay-Alsek Route

The lower Alsek river valley lies transverse to the St. Elias range and has been proposed as a route into the interior. The line would run southeastward from Yakutat bay for about 50 miles to the mouth of the Alsek. A narrow-gauge railway, called the Yakutat Southern, has already been built for about 9 miles of this distance for the purpose of bringing fish to the salmon cannery at Yakutat. The Alsek valley is only in part surveyed, but no doubt a railway could be built through it. It would intersect the Pyramid harbor-Tanana route about 200 miles from the coast and would there attain an altitude of about 2500 ft. Yakutat bay, which is about 1150 statute miles (1000 nautical miles) by sea from Puget Sound, is but an indifferent harbor and, so far as known, the proposed railway would not tap any mineral deposits, though such may exist in the unexplored St. Elias mountains. It is open to the same objection as the Pyramid harbor route, for it passes through Canadian territory.

Routes to Bering River Coal-Field

The surveyed portions of the Bering river coal-field include about 45 square miles known to be underlain by high-grade steaming and coking bituminous and anthracite coal. The field lies on the coastal flank of the Chugach mountains and extends into the unsurveyed portion of the mountains. The coal-field lies about 12 miles in an air line north of Controller bay, 12 miles northeast of Katalla bay, and 50 miles east of Orca bay, an arm of Prince William sound. The southwestern end of the field touches Bering lake, which is a very shallow tidewater inlet of Controller bay. Three general routes of approach to the coal-field have been surveyed, and each has been advocated as the best by engineers who were familiar with local conditions. These are: (1) from Controller bay, (2) from Katalla bay and Fox islands, and (3) from Cordova on Orca bay. Controller bay, as a whole, is a shallow body of water, with, however, a deep channel sheltered from the Pacific by Ocalee spit, Kayak, Wingham, and Kanak islands. Controller bay is bounded on the north by the mainland, here a treeless coastal swamp traversed by many winding streams and broken near the sea by tidal inlets. A deep waterway called Ocalee channel enters Controller bay between Wingham and Kanak islands. It trends northeastward for about 4¼ miles and is continued beyond, to the east and northeast, for about 3 miles. At the entrance the channel is a little over half a mile wide and has a depth of about 66 ft. at mean low water. It continues for this width about 3 miles, and then narrows to about five-eighths of a mile, and at the big bend shoals to about 42 ft. It maintains this depth of water and width of channel for about 2 miles to the southeast, beyond which it narrows, but except for one shoal 36 ft. deep, practically maintains this depth of water to the extreme end of the channel, where it is a little less than a quarter of a mile wide.

About 3 miles from the entrance a narrow channel, a little over a mile in length, extends northward between Kanak island and the tidal flats. This has a depth of nearly 20 ft. and lies about three-quarters of a mile east of the southern end of Kanak island. Bering river empties into the ocean at the north end of Controller bay.

Those who advocate the Controller bay route contend that it is the shortest way to the coal-field from tidewater and offers the best grade, with very cheap construction of the land line. They also point out that Controller bay is only 1300 statute miles (1100 nautical miles) from Puget sound, as compared with 1400 for Cordova. They contend that while the channel is ample for present shipping, the soft silt bottom could readily be dredged to meet any requirements of the future. Three chief points have been

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made against Controller bay as an outlet of the coal-field. First, it is asserted that cost of a terminal will be so excessive that interest charges will offset the cost of the extra haul to Cordova. Second, that while the bay is sheltered from the sea, the adjacent lands do not afford adequate protection against the winds, which at certain seasons of the year are severe. Third, that the ice which forms on the mud flats and in the mouths of the rivers is carried into the bay in large cakes, which on being moved back and forth by the tide in the narrow channel, will be a serious menace to shipping as well as to the railway approaches. In reply to these criticisms it should be said that Controller bay has now been under observation for a number of years by those who are advocating it as a railway terminal, and that the engineers employed in this work are confident that the advantages of its use are greater than its disadvantages.

The second plan for a railway from the coast near Katalla contemplated making a harbor at the Martin islands by building breakwaters. It was proposed to connect Whale island with the mainland by a causeway, and to connect this island with Fox island by breakwater, and also to extend a breakwater westward from Fox island. The harbor thus formed would have a depth of 24 to 40 ft. The plan was to build a railway from this terminal into the coal-fields and up Copper river along the routes already described. In 1907 work was started on this project and several miles of track was laid, since which time it appears that nothing further has been accomplished.

The third route of approach to the Bering river coal-field is from the town of Cordova, on Orca bay. This route is in part in use by the Copper River railway, now in operation. The railway takes an easterly course from Cordova across the flats, which here intervene between the highlands and the sea. Many small glacial streams but no large rivers are crossed before Copper river is reached. Copper river is crossed 5 to 10 miles below the head of its delta by several bridges connecting islands that lie between the channels. The nearest point to the coal-field is on the east side of the Copper and about 38 miles from Cordova. From this point there are two alternate routes to the coal-field. One of these runs southeastward and reaches the field by way of Katalla. This is on water grade and has already been described. By this route the distance from Cordova to the coal-field is about 90 miles. The other route runs eastward from Copper river, crosses Martin river, and, passing near the southern margin of Martin glacier, climbs to a pass about 350 ft. high, beyond which it descends to the coal-field by way of Lake Charlotte. The distance from Cordova to the coal-field is about 60 miles by this route.

Copper River Routes

As already pointed out, Copper river affords a good route of access into the interior. Three different general routes up the valley of this river have been proposed: (1) from Cordova or Katalla up Copper river, (2) from Valdez across Marshall pass down the Tasnuna to the Copper and up that stream, and (3) from Valdez over Thompson pass down to Tonsina and to the Copper. The first is the longest and is by water grade. The second is over a 1900-ft. pass near the coast, and the third over a 2500-ft. pass, also near the coast. These routes will first be described and next an account of the branch lines will be given.

Cordova-Fairbanks Route. — The town of Cordova is on the east side of Orca bay, which is tributary to Prince William sound. It is about 1400 statute miles (1210 nautical miles) from Seattle and about 60 miles from the entrance to Prince William sound. The harbor at Cordova is well sheltered. Though the channel at the present wharf is only about a quarter of a mile wide, ample provision can be made on Orca bay for terminals for all future needs. Among other projects is an ocean terminal and townsite, which has been located in a broad flat that opens out at the head of Orca bay, 8 miles northeast of Cordova. The Cordova-Fairbanks route extends up Copper river to the mouth of the Gulkana, ascends that river and one of its tributaries, crosses the divide to Delta river, and descends that stream and the Tanana to Fairbanks. The Copper river railway has been built along this route as far as the mouth of the Chitina, where it turns east to traverse the southern margin of the Kotsina-Chitina copper belt. It turns northward at Copper river crossing, and at mile 49 crosses the Copper just above Childs glacier. From this glacier to the

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town of Chitina (mile 131) it follows the west side of Copper river. Above Tasnuna river the building of the line involved much heavy rock work. At Chitina there is a bridge across the Copper, and from there the line is extended up Chitina river for about 66 miles, to the Kennicott-Bonanza mine, its present terminal. From Chitina the route to Fairbanks follows the left bank of the Copper as far as the mouth of Gulkana river, crossing in turn the Tonsina, the Klutina at Copper Center and the Tazlina. Somewhere near the mouth of Gulkana river it would leave the Copper and follow the valley of the former stream as far as its middle fork. Here it would cross the Gulkana and follow the middle fork to its head in a broad gap, some 3100 ft. high. The information at hand indicates that from the Chitina to the pass there would be little or no rock work. For the most of this distance the river valley proper is marked by an escarpment of gravel and silt, which forms the eastern margin of the Copper river plateau. From the pass the route would descend to the Tangle lakes and thence follow the outlet stream draining these to Delta river. An alternative route would follow the Gulkana to the lake at its head and then cross to the Delta over a divide about 3300 ft. high. There is also another pass, about 3000 ft. high, between Gulkana lake and the Tangle lakes, which might be preferable.

The route down Delta river would run along the east side of the valley to avoid a glacier that discharges from the west, so that it would be necessary to bridge the Delta below the canyon. In the Delta valley considerable rock work would be required. After crossing the Delta the route would lead probably nearly straight to Fairbanks, a bridge being built across the Tanana. One bridge could be avoided by following the Delta to its mouth and then bridging the Tanana, but this would increase the length of track about 14 miles.

Route from Valdez to Fairbanks by way of Marshall Pass.—Surveys have been made for a railway from Valdez to Copper river by way of Marshall pass. The town of Valdez is at the head of Port Valdez, a northeastern arm of Prince William sound. The bay is deep and well sheltered and affords excellent conditions for wharves and terminal facilities. Several townsites have been located on the bay, but Valdez, built on the delta of the streams draining Valdez glacier, is the only important settlement. It is about 1420 statute miles (1230 nautical miles) from Seattle. From Valdez to Marshall pass (elevation 1900 ft.) the distance is about 30 miles, and the route would lie up Lowe river. Engineers report that a good deal of rock work will be necessary for about half this distance. Beyond the pass the route would descend the broad valley of Tasnuna river to the Copper, which would be reached in about 31 miles. From this point the route would be identical with the one up the Copper, already described. The distance from Valdez to Fairbanks by this route is about 380 miles.

Route from Valdez to Fairbanks by way of Thompson Pass.—Thompson pass is about 8 miles west of Marshall pass, and the route to it from Valdez is up the Lowe river valley, which it leaves about 18 miles from tidewater. Here it turns northward, and in a distance of about 15 miles more crosses Thompson pass (elevation about 2500 ft.). A better grade can be obtained by swinging around toward the head of Lowe river, thus increasing the mileage of approach to the pass. Beyond the pass the route follows down Tsina river to the point where that stream joins the Kanata to form the Tiekel. It then follows up the Kanata valley to Ernestine pass and crosses a divide, about 1800 ft. high, to Mosquito creek, which it follows to its junction with the Tonsina. Beyond Tonsina there are two alternative routes; one would follow the Tonsina valley to the Copper and would be the natural route to the Chitina valley; the other would keep to the north and, after climbing about 400 ft., would join the Copper river route about 10 miles below Copper Center. From there on the route to Fairbanks would be identical with the one already described from Cordova. The distance from Valdez to Fairbanks by this route is about 342 miles.

Chitina Valley and White River Routes.—A trunk line up the Copper valley will necessitate a number of feeders to reach the mining camps tributary to it. The present railway up the Chitina valley can be regarded as the most important of these feeders, but this itself will have to be supplemented by a number of spurs to reach many of the copper deposits. It has been suggested that this line be extended up Nizina and Chiti-

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stone rivers to Skolai pass and across the divide to the White river copper deposits. It appears that the distance to the pass from the nearest point on the railway is about 25 miles, and from the pass to the flats at the head of White river is about 15 miles. Skolai pass, which is occupied by a glacier, stands probably less than 5000 ft. above the sea. The railway at the proposed junction point has an elevation of about 1400 ft., whereas the White river flats, on the other side, are approximately 4000 ft. above the sea. This route traverses a rugged mountain region and would be expensive to construct. A railway reaching White river by this route would tap only the eastern end of the copper-bearing zone. The western end is in the Tanana drainage. To reach this by direct route from White river would necessitate crossing a divide about 6400 ft. high, to Chisana river, the east fork of the Tanana, a distance of about 25 miles, where a descent to about 4000 ft. would be made. The route would then be continued northwestward over the Cooper pass (5600 ft.), and in a distance of about 25 miles would reach Nabesna river, the west fork of the upper Tanana. At the Nabesna the elevation would be about 3000 ft. The same districts could be reached from White river on water grade, but by a very circuitous route, by extending the railway down the White valley and cross the flat which separates it from the Tanana basin. Then, by building down the Tanana valley, the upper Chisana and Nabesna regions could be reached by branch lines. This would require a total length from White river of about 160 miles, but the road would be easy of construction.

Route from Copper River to Matanuska Coal-Field.—A project for building a railway from Copper river to the Matanuska coal-field has received some consideration. The route leaves Copper river at the mouth of the Tazlina (elevation about 1100 ft.), about 7 miles above Copper Center, 114 miles from Valdez by way of Thompson pass, and 182 miles from Cordova, and follows up the Tazlina for about 50 miles to a point within 10 miles of its glacial source. Here the route would reach an altitude of about 2200 ft. From this point the route ascends to Tanneta pass, about 2800 ft. above the sea, in a distance of about 10 miles. From Tanneta pass it would continue down one of the streams tributary to the Matanuska and reach the easternmost known coal in a distance of about 30 miles, here having an altitude of about 1400 ft. About 18 miles more would carry the railway to the mouth of the Chickaloon (elevation 800 ft.), in the heart of the Matanuska field.

Branch Lines to Upper Copper, Tanana, and White River Region.—A railway through the Copper river valley and down Delta river, without branch lines, would fail to provide for the upper Copper basin and adjacent portions of the Tanana and White basins—a region of much mineral promise. The Chistochina or Chisna gold-placer district could be reached from the main line by branches on several routes. One route would start from the main line, about 20 miles from the Copper and near the Sourdough road-house, would extend across a low divide to Gakona and up that stream to Chisna, centrally situated in the goldfield. This route would be on water grade and would be about 50 miles long. Another route would trend eastward from a point near the Delta river divide, leaving the main line at an altitude of about 3200 ft., lead eastward, passing near Summit lake, and reach Chisna by crossing two low divides in a distance of about 30 to 40 miles. From Chisna a good route, about 50 miles long, extends eastward by way of the Mankomen valley to Mentasta pass, which has an elevation of about 2900 ft. above the sea. There is a good route from Mentasta pass down Tok river to the Tanana, a distance of about 40 or 50 miles. A line could be extended up the Tanana on water grade to the copper deposits of the Nabesna, Chisna, and White rivers, as already described. About 240 miles of track would be required to reach all parts of this copper district. There is a more direct route to the copper-bearing district from Mentasta pass by way of the pass (elevation 3200 ft.) at the head of Little Tok river, which leads into Tuck creek, a tributary of the Tanana. By this route the different parts of the Nabesna-White river copper district could be reached from Mentasta pass by about 240 miles of track.

A more direct route into this copper belt leads up the main Copper river valley from the Gulkana. This route would pass the native settlement of Batzulnetas and ascend Tanana creek to a pass about 3400 ft. high to Jack creek a tributary of Nabesna river. From the Nabesna there are the two alter-

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nate routes to White river, a long one by water grades, and another, a direct route, over two high divides, which have already been described. The distance from the main line at the Gulkana by this route is about 90 miles. It may be added that construction work will be easy in this entire upper Copper river and White river region.

Route from Seward to Fairbanks by way of Turnagain Arm and Susitna Valley

The Susitna valley and Broad pass, at its head leading to the Tanana valley, affords a favorable railway route to inland Alaska. As the upper part of Cook inlet is closed to navigation from about November 1 to April 1, a railway up the Susitna must find an open port on the east side of Kenai peninsula. Such a route has been found to Resurrection bay and is now being utilized by the Alaska Northern railway. This railway has been completed from Seward, on Resurrection bay, to Kern creek, on Turnagain arm, a distance of 71½ miles. The Matanuska coal-field is the objective point of this railway, but construction work has been stopped pending a settlement of the coal-land question. Seward, which is excellently situated at the head of Resurrection bay, is about 1420 statute miles (1235 nautical miles) from Seattle. The harbor is good and the conditions are favorable for terminal facilities.

Before the Alaska Northern railway was built, several other plans were devised for a railway into the Susitna valley. One of these was a route from Kachemak bay northward along the west front of the Kenai mountains to Turnagain arm and around the head of the arm. This route is much longer than the one from Seward and misses most of the important developed gold resources of Kenai peninsula, and its ocean terminal is inferior to that on Resurrection bay. Another plan was to build from Snug harbor or some other bay on the west side of Cook inlet and follow the shores of the inlet northward to the Susitna valley. This route would run on water grade, but would be longer to the Matanuska coal-field than the one from Seward. Its ocean terminal would also be very inferior to that at Resurrection bay and is sometimes blocked with ice. Another plan is to build from Portage bay, on the west side of Prince William sound, to Turnagain arm. Though the distance is only some 15 or 20 miles, the fact that the pass (1000 ft.) is occupied by a glacier seems to prohibit its use for a railway.

The establishment of a summer port of shipment near Ship creek, on Knik arm, is a part of the project of the Alaska Northern railway. The charts of the Coast and Geodetic Survey show that a channel having a depth of about 36 ft. enters Knik arm and extends to the vicinity of Ship creek, which is on the line of the proposed route of the Alaska Northern railway. This is about 60 miles from the Matanuska coal-field, which is reached from this point by water grade. The mouth of Ship creek is about 1650 statute miles (1430 nautical miles) by ocean route from Seattle. This port would be available only from about May to October, being usually impassable during the remainder of the year on account of ice. The Susitna route to Fairbanks traverses an area that includes important gold and coal resources, as well as some of the best agricultural lands in the territory. Whatever may be the relative merits of the routes through the Copper and Susitna valleys to Fairbanks, it is certain that a railway up the Copper cannot develop the resources of the Susitna valley.

Routes from Cook Inlet to the Kuskokwim and Lower Yukon

It is proposed to build a railway from some port on the west side of Cook inlet, through the Iliamna lake region, thence across to the Kuskokwim valley, and from there to the Yukon. Only a part of this region is covered by the Geological Survey maps, and little is known of the topography and resources of the remainder. In 1902 to 1908 a railway route was surveyed by the Alaska Short Line Railway Co. from Iliamna bay westward to the Yukon. Iliamna bay is a deep indentation of the mainland, but the larger part of it is too shallow for ocean-going vessels. Vessels therefore must lie near the entrance, and terminal facilities would be expensive to construct. By ocean route to Iliamna bay is about 1530 statute miles (1330 nautical miles) from Seattle. The proposed railway route leads from a point near the head of the north arm of the bay over a divide about 900 ft. high to Iliamna lake. It then swings around the eastern end of Iliamna lake, crosses the outlet of Clark lake, and extends up Chulitna

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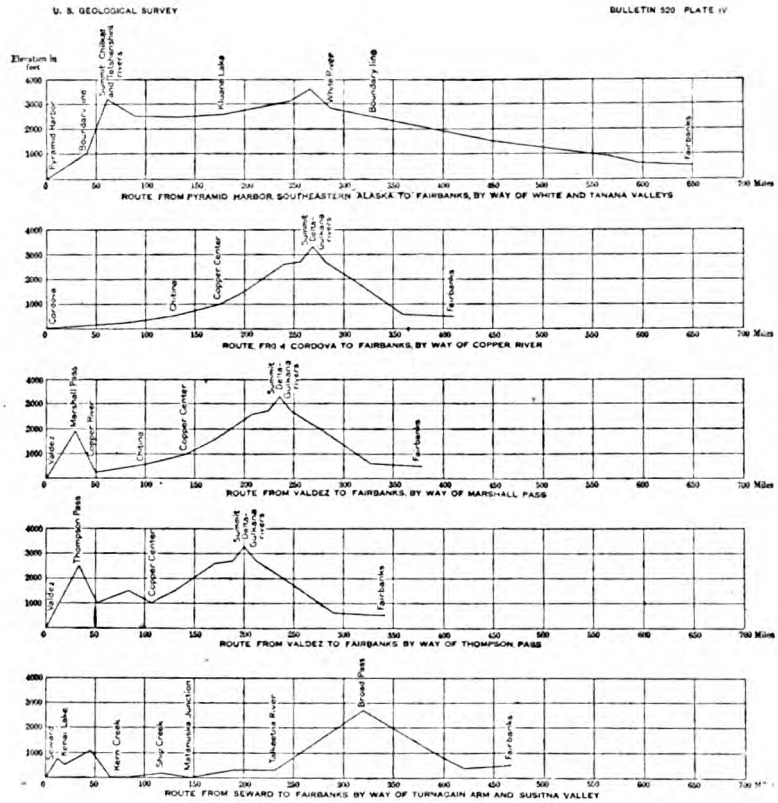
river, crossing a low divide to Mulchatna river. It appears that the divide west of the Mulchatna probably drains into the Kuskokwim and that the proposed railway route would reach the latter stream somewhere near the big bend and not far from the Iditarod placer district. The plan of the Alaska Short Line Railway Co. contemplated reaching Yukon river at Anvik. Plans have also been proposed to extend this line to Nome, on Seward peninsula. No data are at hand regarding distances or altitudes for most of this route. It appears, however, that 450 miles of track should reach the Yukon and that there are no high divides to overcome. It also appears that construction of most of the route would not be expensive. This railway is projected to reach the lower Kuskokwim and Yukon basins, but it would be in a measure a competitive route with the one from the Susitna over Rainy pass to the Kuskokwim.



GENERALIZED PROFILES OF PRINCIPAL RAILWAY ROUTES FROM THE PACIFIC COAST TO FAIRBANKS.
COMPILED, 1912, BY ALFRED H. BROOKS.

California Natural Gas*

By G. N. CROSS

THERE is one locality in the California oilfields which promises to become commercially important in the production of natural gas, namely, the Sunset-Midway district. A single well has for the past two years been producing sufficient gas to supply the entire city of Los Angeles. That this statement is not an exaggeration will be more readily understood when it is known that the initial rock-pressure of the gas

*Abstract from *Jour.* Am. Soc. Mech. Eng., August 1912.

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ANALYSES OF NATURAL GAS FROM THE CALIFORNIA OILFIELDS. PER CENT BY VOLUME REDUCED TO 60 AND 29.82 IN. MERCURY.

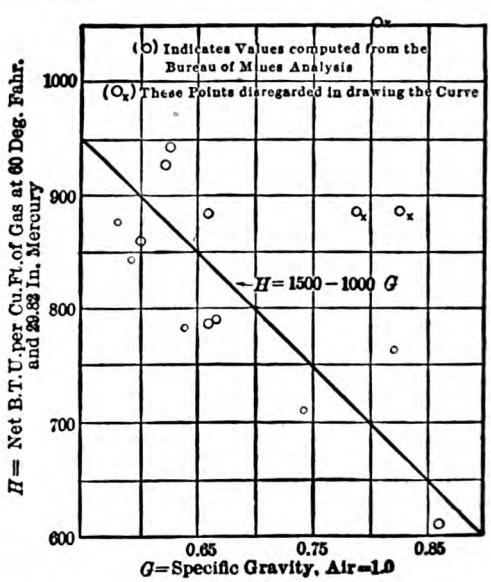
Location. Year	O_2	CO_2	(C_2H_4) (C_2H_6)	CH_4	N_2	Lower B.t.u. Junker Calorimeter.	Lower B.t.u. by Analysis	Lower B.t.u. by Equation	Specific Gravity
Coalinga No. 1....1911	...	19.20	...	79.0	1.8	667	709	754	0.7460
Coalinga No. 2....1911	1.60	3.80	...	94.4	..	776	847	903	0.5974
Sunset No. 1.....1911	...	22.80	10.7	65.9	..	670	762	678	0.8217
Sunset No. 2.....1911	0.70	7.70	...	87.5	3.6	...	785	857	0.6434
Sunset No. 3.....1911	1.30	0.60	3.10	92.3	1.7	921	877	918	0.5824
ANALYSES MADE BY BUREAU OF MINES AND PUBLISHED IN BUREAU OF MINES BULLETIN, No. 19, 1911.									
Santa Maria 1909	0.2	15.5	20.2*	62.7	1.4	...	884	675	0.8254
Santa Maria 1909	0.2	14.1	19.0	64.6	2.1	...	882	709	0.7910
Torry 1910	...	6.8	35.6	54.2	3.4	...	1053	695	0.8051
Coalinga 1910	...	11.1	...	88.0	0.9	...	789	836	0.6640
McKittrick 1909	...	30.4	1.0	66.2	2.4	...	610	638	0.8616
West Los Angeles.1909	0.1	1.0	2.7	91.0	5.2	...	859	902	0.5978
Sunset 1909	...	10.5	...	87.7	1.8	...	787	838	0.6619
Fullerton 1909	...	1.7	9.5	86.7	2.1	...	929	876	0.6241
Fullerton 1909	...	1.4	10.9	85.8	1.9	...	944	873	0.6271
Kern River.....1909	...	6.5	8.0	84.3	1.2	...	884	841	0.6594

*The remainder of this column C_2H_6 only.

There was a trace of H_2 in Sunset No. 2, and of H_2S in Coalinga No. 1 and Sunset No. 1.

in the field is often more than 2000 lb. per square inch. When these gas pockets are first opened the string of tools is often thrown from the well and over the top of a 90-ft. derrick. Sometimes large quantities of sand and boulders weighing 15 to 20 lb. each are ejected from the mouth of the well. Under such conditions there are very lively times getting the well under control. For lack of transportation facilities, this immense quantity of gas is largely being lost.

The table shows analyses of California gases, of which the first five were obtained in connection with my work in the oilfields. The sum total of the constituents of these five samples varies from 99 to 99.9%. This irregularity is due to the fact that the measuring burette used could be read only to the nearest 0.2%, and no attempt was made to determine the rarer gases. The percentage of nitrogen was read from the burette instead of subtracting the sum of the other gases from 100%. The remaining ten sam-



RELATION OF CALORIFIC VALUE AND SPECIFIC GRAVITY FOR CALIFORNIA GASES.

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ples were analyzed by the Bureau of Mines and published in the Bureau of Mines Bulletin, No. 19, 1911. In every case the total of these analyses is 100 per cent.

The peculiar feature of the California gases is the unaccountably high percentages of carbon dioxide present. The fact that California oils are of an asphaltic base may in some way be responsible for the large percentage of carbon dioxide. Roughly, the straight-line law connecting the calorific value and the specific gravity holds for these gases, but the slope of the line which is shown in the diagram, is reversed. This is due to the presence of the carbon dioxide in large proportions.

Production of Gasoline From Natural Gas*

By C. F. HIRSHFELD

THE constantly increasing demand for gasoline and the difficulty experienced in meeting this demand with the product of the oil refineries lend great interest to any other possible method of producing this commodity. Such an alternative method has acquired considerable prominence during the past few years. The process referred to results in the production of gasoline from what is called natural gas. Such gas ranges from 'dry' gas, which consists largely of methane, CH_4, and has a specific gravity of approximately 0.6, to the very heavy vaporous 'head casing gas' rising from oil wells. The latter gas often has a specific gravity greater than unity as compared with air and contains appreciable quantities of the first seven or eight members of the paraffin series of hydrocarbons—that is, methane, ethane, propane, butane, etc. Little, if any, gasoline can be recovered from dry gas; comparatively large quantities can be obtained from the heavier varieties.

The plant required for the recovery of gasoline from gases of this kind is very simple and comparatively inexpensive. It will be shown later that several distinctly different methods might be used, each involving characteristic apparatus. At present, however, there is practically only one method and type of plant in use. This is shown diagrammatically in Fig. 1. In this figure *a* is a compressor, *b* a cooler or condenser, *c* a separator, *d* a trap, and *e* a pressure-regulating or relief valve. In operation, gas is compressed in *a*, cooled at practically constant pressure as it passes through *b*, and the liquid gasoline which results is separated at *c*, from which it drains into the trap *d*. The trap discharges the gasoline into a convenient storage vessel or tank. The gas from which the gasoline has been removed passes through the relief-valve to a distributing pipe system or to waste. It will be observed that this apparatus is merely a simple modification of that used when natural gas is to be prepared for pipe-line transmission. Indeed the process is merely an outgrowth of such preparation. It was often observed that a liquid drained out of natural-gas lines, particularly when the pressure was high and the temperature happened to be low. When investigation showed this liquid to be a high-grade gasoline, little further incentive was required to bring about the perfection and commercialization of the process just described.

Experience has shown that as many as eight or nine gallons of high-grade gasoline can be obtained per thousand cubic feet of heavy gas with specific gravity of approximately 1.1 referred to air. In general, the possible gasoline recovery decreases as the specific gravity of the gas decreases, becoming practically zero with a specific gravity of approximately 0.6.

In the early days of the recovery of gasoline from natural gas the process was shrouded in mystery. Even at the present time many of the users of the process have no very clear idea of the principles involved; operation is controlled largely by a cut-and-try method and nearly all data are empirical. The phenomena involved can be simply explained in a more or less general way and considerable of the air of mystery thus dispelled.

We shall assume for this purpose that the process is entirely a physical one; that is, that it involves no chemical changes. The

*Abstract from *The Engineering Magazine*, September 1912.

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absolute correctness of this assumption has not yet been proved, but it seems almost certain that no chemical changes of any magnitude occur. According to this assumption we must assume that the natural gas as produced from the well contains in gaseous form the hydrocarbons which will later be

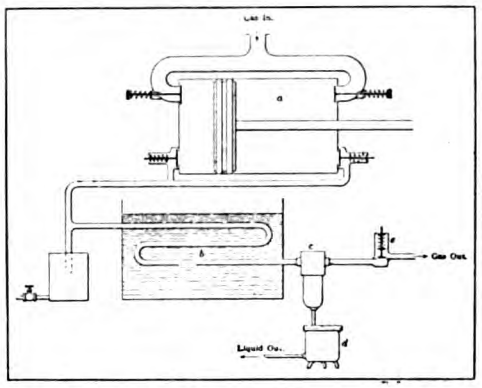

FIG. 1. DIAGRAMMATIC REPRESENTATION OF COMPRESSOR.

obtained as liquid gasoline. These hydrocarbons may be pictured as existing in the natural-gas mixture in much the same way as water-vapor, humidity, exists in the mixture which we call air. It will help in following the discussion if this viewpoint is constantly kept in mind.

It is well known that commercial gasoline is not a definite chemical compound, but merely a mixture of such compounds. The better grades of gasoline are mixtures of very closely related hydrocarbons of the kind previously mentioned as occurring in heavy gas. They have very nearly the same boiling points and all other properties are closely related. If the average boiling point is about right, if the average density is about right, and if upper and lower limits are not too widely separated, the mixture can be marketed as gasoline.

Our problem is to determine the physical condition of such gasoline-forming compounds when in the gas, and the methods by which they can be changed from gaseous form to a liquid which can be handled and transported as such, at ordinary temperatures and pressures. The problem is best approached by means of diagrams such as those shown in Fig. 2, 3, and 4, which may be called liquid, vapor, and gas diagrams, or simply physical equilibrium diagrams. These diagrams are plotted to pressure and volume co-ordinates, pressures being plotted vertically and volumes horizontally. It is convenient to plot in terms of specific volumes; that is, volumes per pound of material. Any point in the diagram represents the volume occupied by a pound of material at some definite pressure and, as we shall learn shortly, at some definite temperature.

To construct such a diagram, assume that the point a_1 in Fig. 2 represents the volume of one pound of some liquid under a high pressure P_a and at a temperature T_1. If the pressure upon the liquid is decreased while the temperature is maintained constant, the volume of the liquid will, in general, increase slightly as shown by the inclination of the line a_1, b_1. Such a process could be continued until at some point, b_1, the pressure attained corresponded to that of the saturated vapor of the material in question at the temperature T_1. The condition of the material at this point would correspond exactly to that of water at steam temperature in a steam boiler. Any attempt to lower the pressure upon such water would result only in the vaporization of some, or all of it, at constant pressure if provision were made to maintain a constant temperature. To maintain this constant temperature it would only be necessary to supply the requisite heat of vaporization. This will be recognized as just what takes place continuously when a boiler is supplying steam.

Returning now to the material, the condition of which was supposed to be represented by the point b_1 in Fig. 2, if the volume is allowed to increase while the temperature is maintained constant as before, the liquid will vaporize at constant pressure. The mixture of liquid and vapor will occupy successively larger and larger volumes as represented by the points c, d, e, etc., until, when the last particle of liquid disappears, the volume occupied will be the specific volume of the dry saturated vapor of the material in question when at temperature T_1. This volume is represented by the abscissa of the point g_1 in the figure. A further reduction in pressure with the maintenance of the same constant temperature will result in the formation of unsaturated or superheated vapor. The material in this state will behave somewhat like an ideal gas, the relation between pressures and corresponding volumes being such as to give the curve

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g_1h_1 resembling the rectangular hyperbola representing a similar change for an ideal gas.

The broken line $a_1b_1g_1h_1$ may now be seen to represent an isothermal expansion of the material in question from the liquid condition at a_1 to a superheated vapor at h_1. It may be called the T_1 isothermal. If we start again with one pound of the same liquid at the same pressure P_a, but at a higher temperature T_2, it will in general occupy a greater volume, as shown at a_2. Expanding isothermally as before but at temperature T_2 will give the broken line $a_2b_2g_2h_2$ similar to $a_1b_1g_1h_1$ but higher in the field. This is to be expected, as it is common experience that the pressure exerted by the saturated vapor of a material is higher the higher the temperature. Similar isothermals are shown for still higher temperatures in the same diagram, and it will be observed that all have the same characteristic shape until the T_4 isothermal is reached. This exhibits no constant pressure volume increase, which indicated vaporization on the preceding isothermals; that is, points b_4 and g_4 coincide.

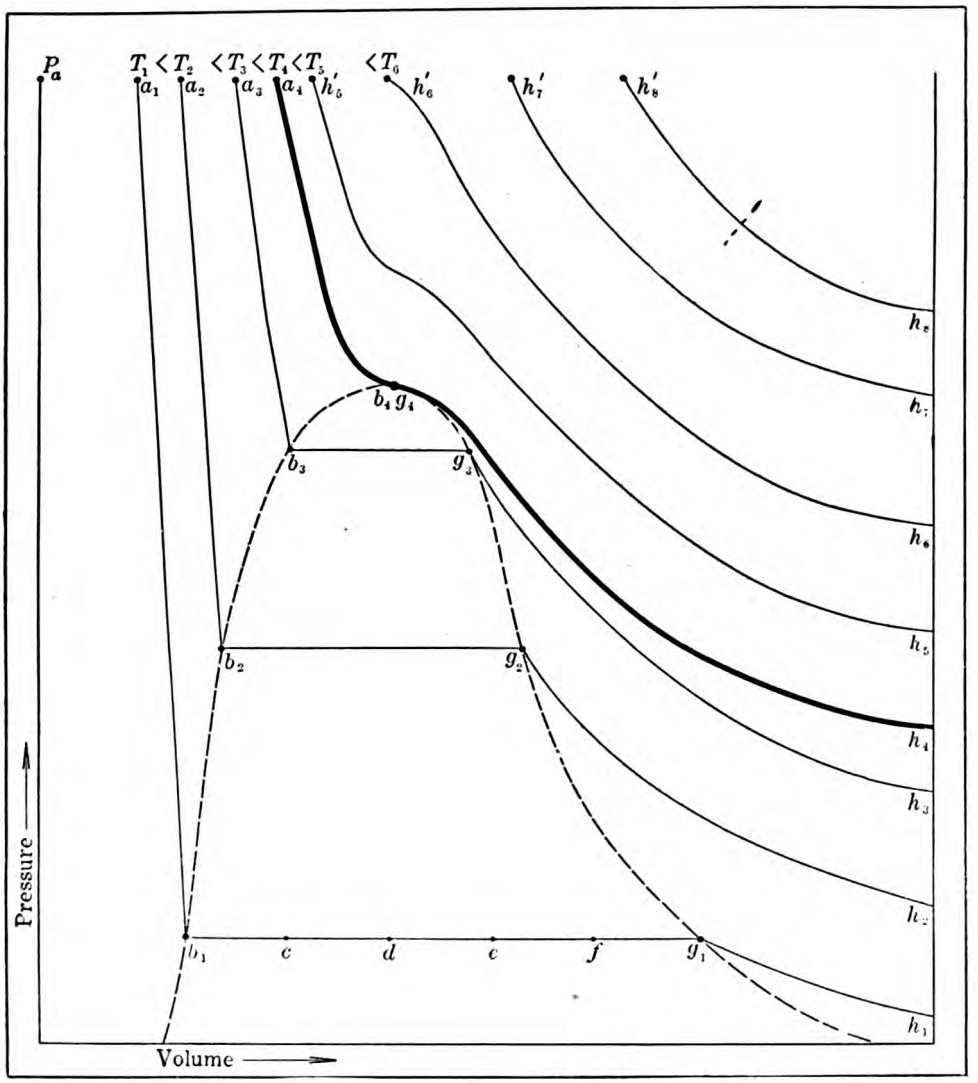

FIG. 2. PHYSICAL EQUILIBRIUM DIAGRAM

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Isothermals at still higher temperatures resemble those below less and less as the temperature rises and approach in shape more and more closely the rectangular hyperbola which is characteristic of the ideal gas.

If all the points b_1, b_2, b_3, etc., and all the points g_1, g_2, g_3, etc., be joined as in Fig. 2, it becomes evident that they lie on two curves which converge at the common point b_4g_4. Remembering that vaporization occurs whenever any of the isothermals cross to the right of the curve $b_1b_2b_4$ and that the increase of volume during vaporization is represented by the lengths of the lines b_1g_1, b_2g_2, etc., it is obvious that the T_4 isothermal, which is tangent at b_4g_4, represents some sort of limiting condition. This condition can be best realized by tracing the lines *abgh* in the reverse direction. Starting, then, at h_1, h_2, etc., the material is a superheated vapor. When any of the points g_1, g_2, etc., are reached, liquefaction, that is, condensation, begins and it is complete when points b_1, b_2, etc., are reached. Starting with h_4 it is found that there is no horizontal line g_1b_4, but that these two points have become coincident. The T_4 isothermal therefore represents temperature conditions above which no liquefaction can occur and below which liquefaction must occur. In this sense it is a limiting isothermal. The temperature T_4 is called the critical temperature and the pressure and volume at b_4 are called critical pressure and critical volume.

For our present purpose it is convenient to divide the equilibrium diagram into several areas or fields as indicated in Fig. 3. That part lying below the critical isothermal from a_4 to b_4 and to the left of the curve b_4 b, evidently represents a field in which the material for which the diagram is plotted must be all liquid. That is, any point in this field represents the volume of one pound of the liquid at some definite temperature and pressure. The space below the critical-temperature isothermal and to the right of the curve b_4g_1 is similarly the field of unsaturated or superheated vapor. This is easily realized by remembering that decrease of temperature from any point in this field will first bring the material to the condition of dry saturated vapor and then will cause liquefaction if continued further.

The space within the curve $b_1b_2g_4g_1$ represents a field of mixed liquid and saturated vapor, varying from all liquid at the boundary b to all saturated vapor at the boundary g. The remaining area, that above the isothermal T_4, represents what may be called the gas field. This will be brought out more clearly in subsequent paragraphs. The great use of this diagram from an engineering viewpoint comes from the fact that it enables us to visualize the results of real or assumed processes which result in pressure, volume, and temperature changes. For instance, if we start with material in the liquid state, as at point *o* in Fig. 3, and increase the volume at constant pressure, it is evident that we must also raise the temperature of the material because the line *oo'* cuts isothermals of successively higher temperatures as it is drawn to the right. The material in question will eventually vaporize, as shown by the fact that the line *oo'* enters the mixed field, and after complete vaporization it will become superheated. This whole process will be recognized as that which takes place in a superheating steam boiler which is supplied with feed water at a temperature below that corresponding to the pressure carried. Any other line traced through the various fields to represent an assumed process would indicate in a similar way just what physical states the material must pass through. It is obvious that starting with any point in the gas field, it is impossible to bring about liquefaction by any process which does not involve crossing of the critical isothermal. From this fact the common definition of the critical temperature follows, that is, the critical temperature of a gas is the temperature above which it cannot be liquefied by any increase of pressure or decrease of volume. It should be noted that the higher its critical temperature the more easily can a material be liquefied under ordinary conditions, while those materials which have very low critical temperatures are liquefied with difficulty and are known as permanent gases.

With the aid of such diagrams as these the manufacture of gasoline from natural gas is easily visualized and the reasons for the various steps can be appreciated. Those constituents of the gas, which will later be condensed to form gasoline, exist in the gas as superheated or saturated vapors mixed with other superheated vapors of lower critical temperatures and with gases which have still lower critical temperatures. Just

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what may be the chemical constitution of the gasoline-forming vapors is really immaterial for our present treatment. For the double purpose of simplifying the problem and of having a definite material to think of, we shall, however, assume that there is but one such constituent in the gas, and we shall call it vapor X. It would, in a real case, have a chemical formula of the type form C_xH^y and would be mixed with other vapors with similar formulas.

If now a certain quantity of the natural gas is assumed as existing at atmospheric temperature and pressure, it contains a certain weight of vapor X which exerts a partial pressure less than atmospheric. This must be true because the sum of the partial pressures exerted by each of the constituents must equal that exerted by the mixture, namely, atmospheric. As the vapor X is below its critical temperature and as none of it is liquid it must be either a dry saturated or a superheated vapor. In a real case it will, in general, exist as a superheated vapor and the conditions of one pound of it may be represented by a point such as p in Fig. 4. This figure is a reproduction of part of Fig. 3 with changed pressure scale. The point p indicates that one pound of the vapor when mixed with the rest of the gas fills a volume V_p, exerts a low pressure P_p, and has a temperature t which may be assumed at about 60°F. Its temperature must at any rate be the same as that of the gas of

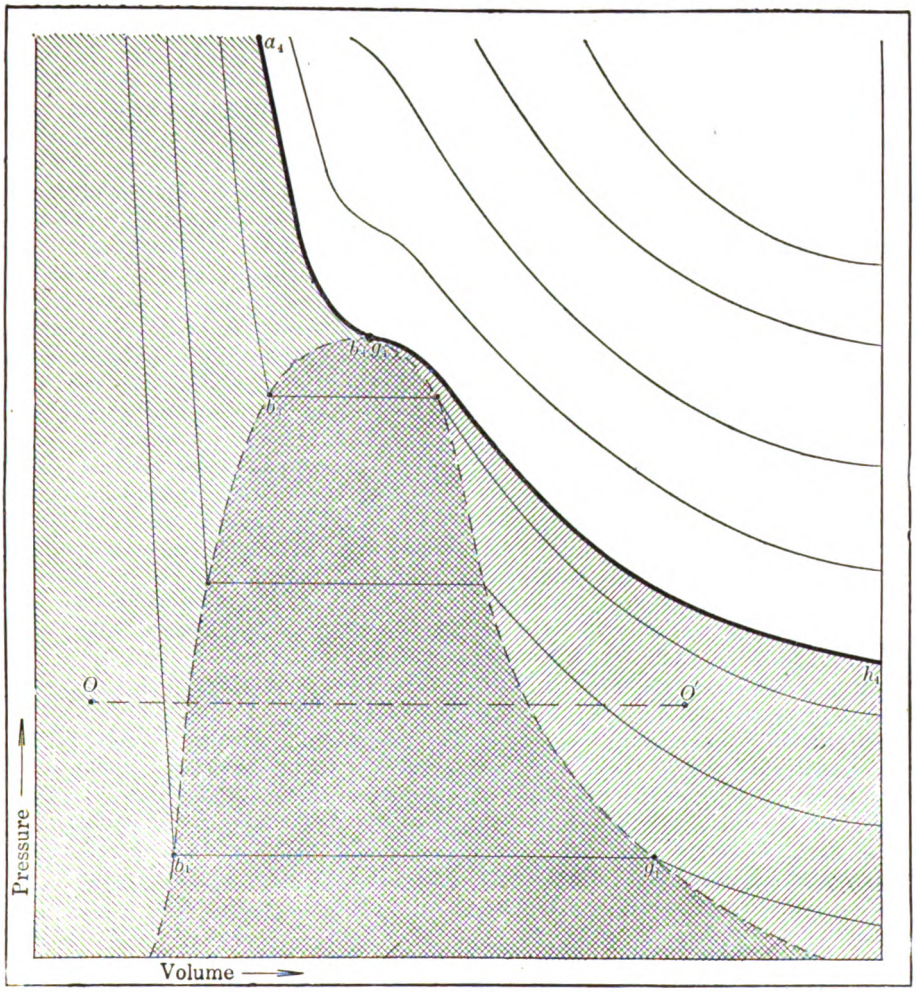

FIG. 3. PHYSICAL EQUILIBRIUM DIAGRAM.

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which it forms a part.

The vapor could be liquefied by keeping the pressure of the mixture, and therefore of each constituent, constant and decreasing the volume as indicated by the line pp_1. This process would, however, in general necessitate cooling to a temperature much lower than the assumed initial value of 60°F. as shown by the fact that the line pp_1 cuts isothermals of lower and lower temperatures in the vapor and liquid fields. As it will, in general, be most convenient to do any necessary cooling by means of surface or well water, liquefaction according to the line pp_1 may be commercially impossible.

This difficulty can be overcome in several ways. If the gas as obtained from the well has a temperature slightly above that of the available water, it can be compressed isothermally so that the vapor X behaves as shown by the line h_1g_1 in Fig. 4. If the relation between gas and water temperatures happens to be about right, this process may be continued until the pressure reached by the vapor X is such that cooling with the available water will cause the decrease of volume at constant pressure shown by the line qq_1. This obviously results in complete liquefaction of the vapor if carried far enough. Or, the gas might be compressed by a process more nearly adiabatic; a method which would give the curve pr for the constituent X might be used in a real case. This compression would be accompanied by a rise of temperature as indicated by the fact that the curve crosses isothermals of successively higher temperatures. It then becomes merely a question of carrying the compression to such a point that the temperature has risen to a value so high that cooling with the available water can cause liquefaction, as, for instance, along the line rr_1. As indicated on the diagram, water at 60° F. could theoretically be used in this case. It will be observed that this is substantially the process which is carried out in the apparatus shown in Fig. 1. It is the only process which has been widely used commercially, but this does not imply that it is the best nor the most economical. Two other possibilities will be described as an example of what might possibly be done in this field.

One of these methods is particularly startling because of its apparent unreasonableness. It would consist in heating the gas so as to cause a rise of pressure at constant volume. It might easily be done by burning a small amount to heat a much larger quantity. The pressure rise for vapor X which we have assumed would be about as shown by the line ps in Fig. 4. When the mixture has been brought to such a condition that the state of the vapor is as shown by point s, liquefaction can be effected by cooling at constant pressure along the line ss_1, in about the same way as is now used commercially. No compressor is necessary with this method and yet the same result is attained.

Another possibility is to compress the gas approximately adiabatically to a high temperature, to cool it at constant pressure, and then to allow it to expand behind a piston so as to do work. It might, for instance, assist in compressing the gas which follows it through the process. If the vapor X has properties similar to those of steam, it can be made to partly liquefy by this treatment; if, on the other hand, its properties are similar to those of ether, no liquefaction will take place. The data necessary to determine which action will occur are not yet available. If liquefaction could be brought about in this way it would be only partial, so that the process does not promise as well as that in use. It should, however, be observed that no cold cooling-medium is needed; hot air might be successfully used. The process is therefore of interest as representing a possible way out of a case where cooling water is not available.

The calorific value of the gas will be lowered to a slight extent by removing the gasoline-forming vapors, but this is justified by the fact that it is generally possible to sell a given number of b.t.u. in the form of gasoline at a higher price than could be secured for the same heat value in the form of natural gas. It is also often necessary to remove some of these vapors in liquid form before transmission of gas in pipe-lines, as they condense out naturally during the compression of the gas, so that the installation of the simple machinery, required to obtain the maximum yield of gasoline, may result in perfecting a process already incompletely carried out.

The diagrams previously given also assist in visualizing the conditions which must be met in order that the liquid may be readily handled and transported. Let us first consider a quantity of liquid water in an open

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vessel. We know that with an atmospheric pressure of 14.7 lb. per square inch this water will boil if raised to a temperature of 212°F. This means simply that the pressure of the saturated vapor of water is 14.7 lb. per square inch at a temperature of 212°F. If the diagram of Fig. 3 were drawn for water the horizontal part of the 212° isothermal would pass through the mixed field at a height of 14.7 pounds.

Obviously any material can be commercially handled in liquid form with least loss when the temperature at which the pressure of its saturated vapor is equal to that of the atmosphere is very high as compared with average atmospheric temperature. The relation of temperature and pressure is well shown by the diagrams given.

Such diagrams, drawn for the different constituents of the gas which can be liquefied to form the mixture known as gasoline, will indicate the relative ease of handling. If any of the constituents show that the isothermal crossing the mixed field at a pressure of 14.7 lb. has a temperature near that of the atmosphere, that particular constituent will form a very volatile liquid and, if it occurs in large quantities, will give similar properties to the mixture of which it will form a part.

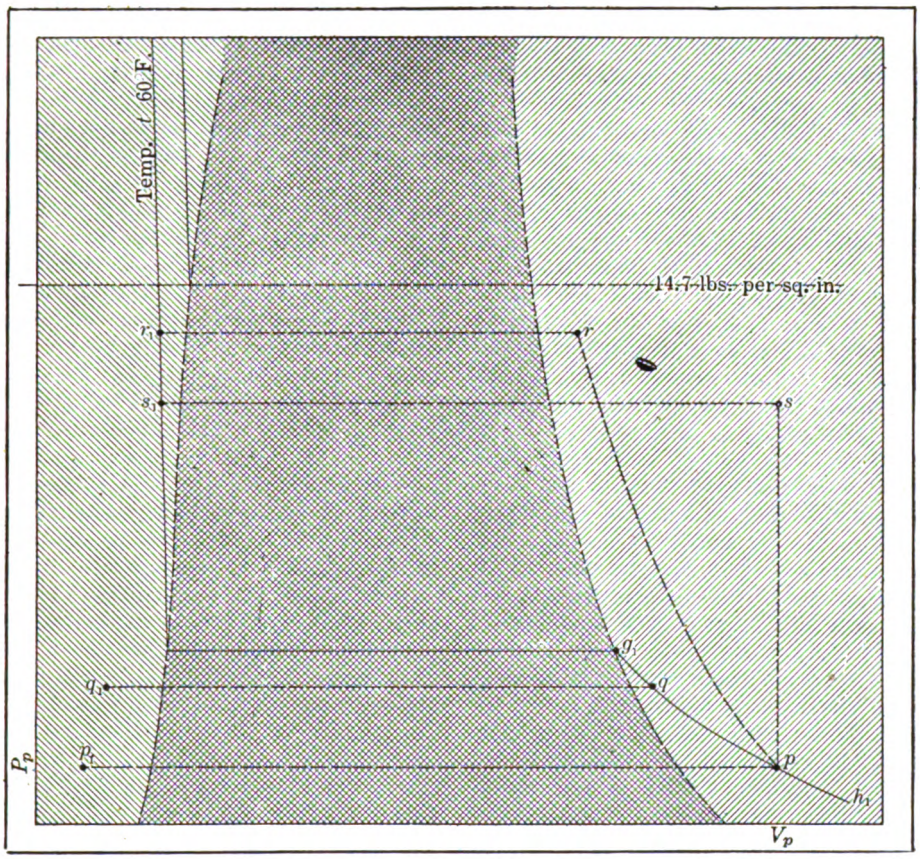

FIG. 4. PART OF FIG. 3 WITH CHANGED PRESSURE SCALE.

Water could not readily be handled and transported commercially at this temperature, even if average atmospheric temperature happens to be 212°F. The loss would be too great because of the rapid evaporation. Any practical temperature of transport and handling must be below this value; the lower, within the limit, the better. In other words, the nearer the temperature to the boiling point of the water the greater will be the loss.

Ordinary gasoline of good quality behaves

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which it forms a part.

The vapor could be liquefied by keeping the pressure of the mixture, and therefore of each constituent, constant and decreasing the volume as indicated by the line pp_1. This process would, however, in general necessitate cooling to a temperature much lower than the assumed initial value of 60°F. as shown by the fact that the line pp_1 cuts isothermals of lower and lower temperatures in the vapor and liquid fields. As it will, in general, be most convenient to do any necessary cooling by means of surface or well water, liquefaction according to the line pp_1 may be commercially impossible.

This difficulty can be overcome in several ways. If the gas as obtained from the well has a temperature slightly above that of the available water, it can be compressed isothermally so that the vapor X behaves as shown by the line h_1g_1 in Fig. 4. If the relation between gas and water temperatures happens to be about right, this process may be continued until the pressure reached by the vapor X is such that cooling with the available water will cause the decrease of volume at constant pressure shown by the line qq_1. This obviously results in complete liquefaction of the vapor if carried far enough. Or, the gas might be compressed by a process more nearly adiabatic; a method which would give the curve pr for the constituent X might be used in a real case. This compression would be accompanied by a rise of temperature as indicated by the fact that the curve crosses isothermals of successively higher temperatures. It then becomes merely a question of carrying the compression to such a point that the temperature has risen to a value so high that cooling with the available water can cause liquefaction, as, for instance, along the line rr_1. As indicated on the diagram, water at 60° F. could theoretically be used in this case. It will be observed that this is substantially the process which is carried out in the apparatus shown in Fig. 1. It is the only process which has been widely used commercially, but this does not imply that it is the best nor the most economical. Two other possibilities will be described as an example of what might possibly be done in this field.

One of these methods is particularly startling because of its apparent unreasonableness. It would consist in heating the gas so as to cause a rise of pressure at constant volume. It might easily be done by burning a small amount to heat a much larger quantity. The pressure rise for vapor X which we have assumed would be about as shown by the line ps in Fig. 4. When the mixture has been brought to such a condition that the state of the vapor is as shown by point s, liquefaction can be effected by cooling at constant pressure along the line ss_1, in about the same way as is now used commercially. No compressor is necessary with this method and yet the same result is attained.

Another possibility is to compress the gas approximately adiabatically to a high temperature, to cool it at constant pressure, and then to allow it to expand behind a piston so as to do work. It might, for instance, assist in compressing the gas which follows it through the process. If the vapor X has properties similar to those of steam, it can be made to partly liquefy by this treatment; if, on the other hand, its properties are similar to those of ether, no liquefaction will take place. The data necessary to determine which action will occur are not yet available. If liquefaction could be brought about in this way it would be only partial, so that the process does not promise as well as that in use. It should, however, be observed that no cold cooling-medium is needed; hot air might be successfully used. The process is therefore of interest as representing a possible way out of a case where cooling water is not available.

The calorific value of the gas will be lowered to a slight extent by removing the gasoline-forming vapors, but this is justified by the fact that it is generally possible to sell a given number of b.t.u. in the form of gasoline at a higher price than could be secured for the same heat value in the form of natural gas. It is also often necessary to remove some of these vapors in liquid form before transmission of gas in pipe-lines, as they condense out naturally during the compression of the gas, so that the installation of the simple machinery, required to obtain the maximum yield of gasoline, may result in perfecting a process already incompletely carried out.

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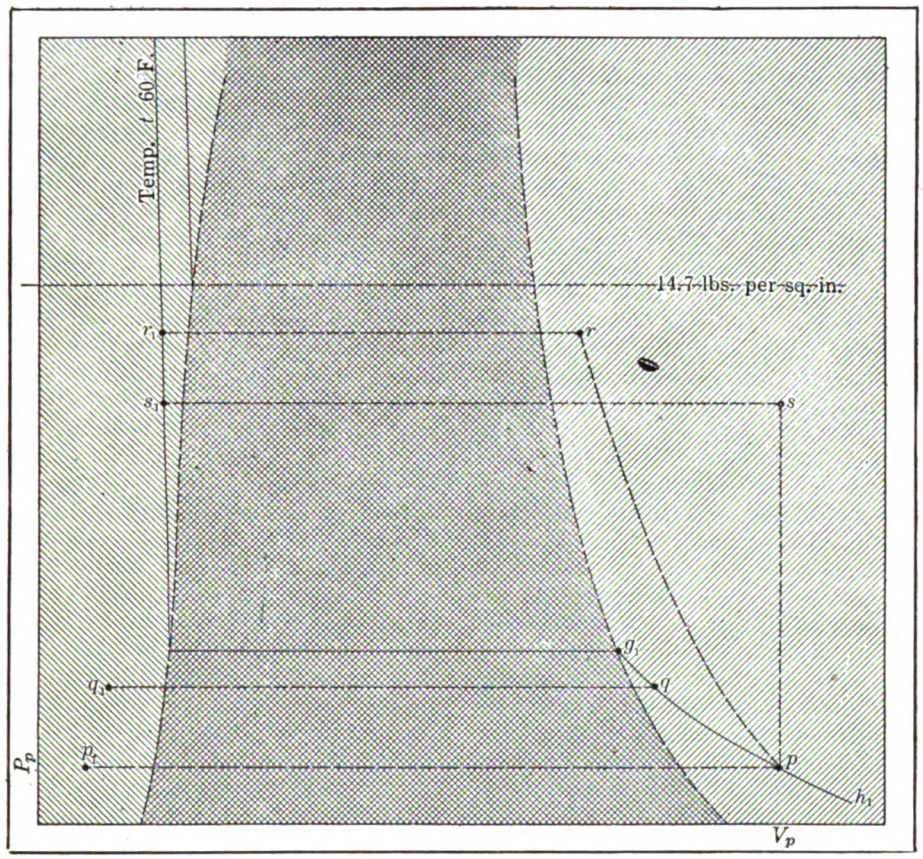

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in such a way that if it consisted of but one chemical compound the 150° isothermal would cross at 14.7 lb. and the 60° isothermal at a height of about 0.2 of an atmosphere. This material can be handled without difficulty at ordinary temperatures, but evaporation takes place with such rapidity that it is necessary to employ closed vessels whenever circumstances require transportation of the liquid over any great distance.

A Graphic Solution for Engine Plane Loads*

By ARTHUR O. GATES†

IN hoisting with skips from deep inclined shafts or hauling trains of cars on flatter inclines, the effect of the inclination is to make the pull on the rope less than the total weight handled. This reduction in rope pull allows greater loads to be handled, and the accompanying diagrams are for the purpose of determining at a glance the rope pull due to a weight of 1000 lb. gross when operating on the various angles and grades shown. When a load W is supported on an incline, the actual support consists of two components, a normal force N at right angles to the track, and a force P, parallel to the track. The resultant of these two is, of course, equal and opposite to W. The circle diagram developed from this relation is interesting, depending on a simple geometrical law which can be stated in several ways. Given a series of right triangles with a common hypotenuse, the intersection of the right angles will lie on a circle the diameter of which is the hypotenuse. Stated another way: If from any point on a circle, straight lines be drawn to the opposite ends of a diameter, the included angle is a right angle.

It will be noted that the gross weight $W = 1000$ lb. has been plotted as the vertical diameter of the circle and is the pull P when the angle of inclination is 90°. At any other angle than 90° the pull P is measured by the distance from the lower end of the diameter to the intersection of the circle and the line drawn at the true angle, measured, of course, on the same scale as the vertical diameter. Thus with a gross load of 1000 lb. on an incline 47° from the horizontal the rope pull due to weight alone is 730 pounds.

On inclines the effect of friction of the wheels on the rails is to increase the rope pull when hoisting, and to decrease it when lowering. This friction or 'traction' varies between certain limits; from 15 to 20 lb. per ton normal pressure on the track when track and skip or car are in the best condition, up to 40 and 60 lb., and even more under bad conditions. This traction is proportional to the normal force on the rails and its value can be shown graphically by another circle diagram, this time with the diamater horizontal and equal to the traction on level grade as shown at the bottom of the circle diagram, the traction of 50 lb. for the 1000 lb. gross load (100 lb. per ton) has been laid off horizontally and the circle drawn. The length from the corner to the intersection of this circle and the angle line measures the traction for this inclination. The combined rope pull due to load and traction is obtained by laying off a new circle on the hypotenuse connecting the ends of the vertical, gross-load line and horizontal, traction line, the incline angles being laid off from the bottom of the vertical gross-load line. For the rope pull when lowering, lay off the inclination from the upper end of the vertical gross-load line. The lengths of these lines to their intersection with the circle gives the rope pull hoisting and lowering as in Fig. 2, which figure also shows the partial loads due to the ore only, skip or cars only, and rope. The circles for lowering rope, pulls of rope, and combined rope and skip have their centres on the diameter of the big circle.

For a specific problem, lay off the different gross loads vertically as in Fig. 2, the corresponding traction horizonally, and the exact rope pull may be read off directly to scale. In case the incline changes its direction, the rope must be divided into several parts, the weight of the section of rope nearest the skip and on the same inclination, to-

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*Abstract from the *Engineering and Mining Journal*, August 17, 1912.

†Mining Engineer, 1017 State street, Lafayette, Indiana.

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gether with skip and ore are combined on the circle diagram, and the pull of the rope on other inclines added. There are several ways that this may be diagrammed, but any-

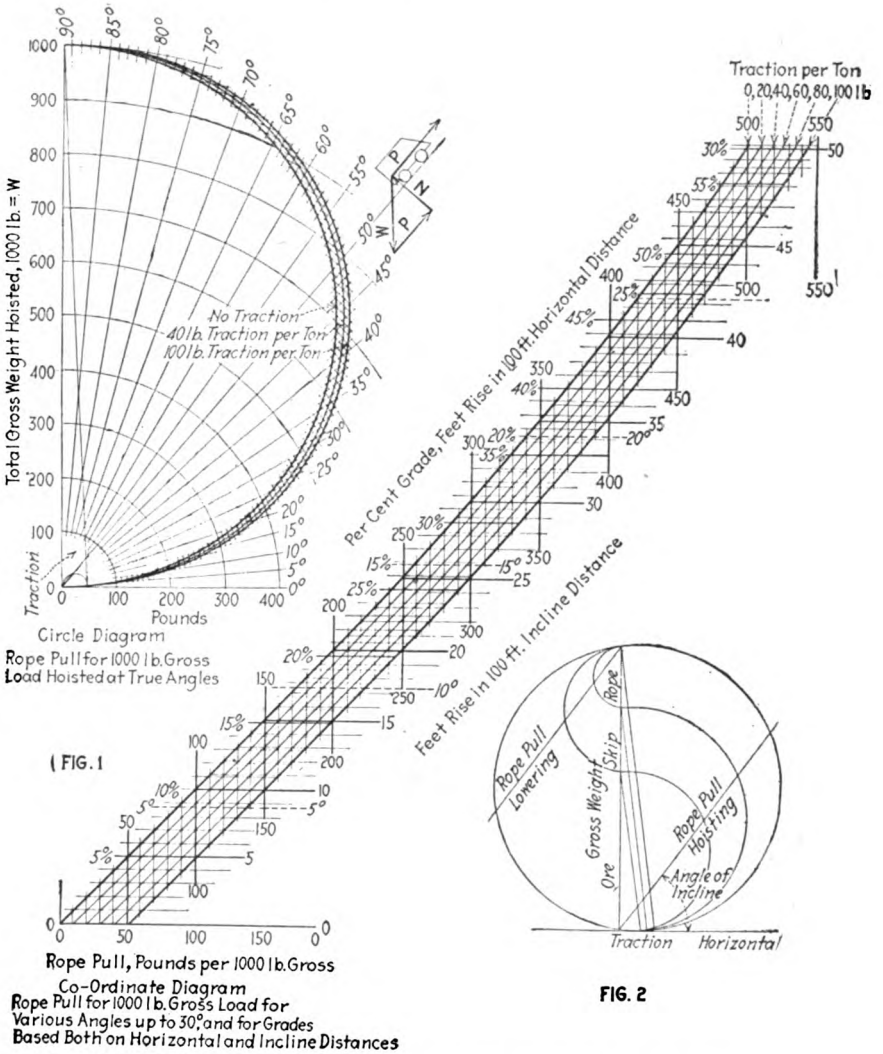

CHART FOR SOLUTION OF FORCES IN HOISTING ON INCLINES.

one familiar with the schemes as outlined need have no difficulty in determining rope pulls for any combination of inclines.

On the flatter grades, the effect of traction is more marked, so for purposes of accuracy that part of the circle diagram under 30° has been plotted to coördinate on a greater scale and which we will call the coördinate diagram. Horizontal distances represent rope pulls when the gross load is 1000 lb., vertical distances marked above the curve indicating per cent grade or rise in feet per 100 ft. horizontal distance; vertical distances marked below the curves, feet rise per 100 ft. along the incline.

The simplicity of the circle diagram and the ease with which it can be remembered makes one wonder if this method has not been used before, although no previous use of it has come to my observation. At any rate, the curve shows how nicely the graphical method shows the effect of variation.

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Kutter and Bazin Formulas: Notes on the Coefficient of Roughness*

By ERNEST W. SCHODER †

IN the use of the Kutter formula in designing open channels the engineer meets (whether or not he recognizes it in precisely this form) the question: If my estimate as to the value of the coefficient of roughness n is wrong or uncertain by a certain percentage, what per cent of error or uncertainty will there be in my estimate of the discharge for a fixed slope, or of the required slope for desired discharge. Simple and important though this question is, the direct answer, and a very simple one, is not to be found in any treatise on hydraulics, as far as I know. Neither is there to be found, let alone emphasized, a direct statement of a simple relation between the value of the coefficient of roughness and the velocity or the slope.

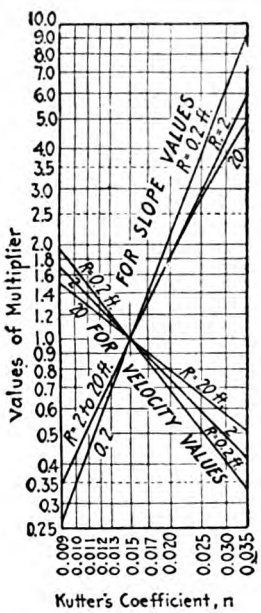

FIG. 1. DIAGRAM OF RELATION BETWEEN COEFFICIENT n OF KUTTER'S FORMULA AND THE CORRESPONDING DISCHARGE AND SLOPE.

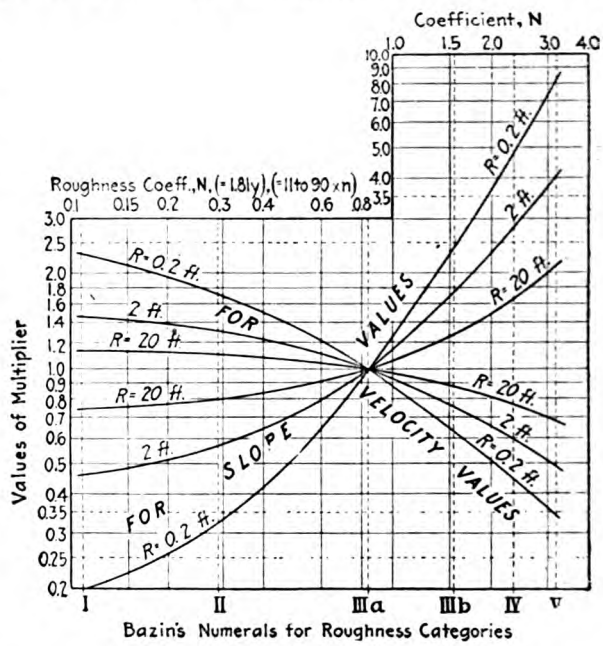

FIG. 2. DIAGRAM OF RELATION BETWEEN COEFFICIENT N OF BAZIN'S FORMULA AND THE CORRESPONDING DISCHARGE AND SLOPE.

If the engineer wants to know the effect of certain variations in n he makes several calculations, usually by diagrams or tables, and compares the results. This is easy, but it leaves no definite general idea in mind for future use. In fact, the common opinion seems to be that the value of n is involved in a complex manner in the velocity coefficient, C, in $V = C\sqrt{Rs}$. This seems to have carried with it the idea that n and V or n and s are intricately, and not simply, connected. For practical purposes the reverse is true.

The following relations hold for the Kutter formula. Other things being equal, (1) the slope s varies as n^2, almost exatcly for all values of the hydraulic radius R greater than 1 ft.; (2) the velocity V varies inversely as n, exactly for $R =$ about 2 ft. and approximately for other values.

*Abstract from *Engineering News*, August 22, 1912.

†Cornell University, Ithaca, N. Y.

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Corresponding to these relations we may state that a certain percentage of uncertainty in the value of the coefficient n produces: (A) double that percentage of uncertainty in the slope necessary for a fixed discharge, and (B) the same percentage of uncertainty, but in opposite direction, in the velocity or discharge resulting from a fixed slope, if the slope is assumed to be greater than 0.0001.

As an illustration of the convenience of this knowledge, suppose that in designing a canal it is uncertain what value in the range between 0.017 and 0.020 to choose for n. This is an uncertainty of about 8% either way from the mean value, and represents a probable occurrence in practice. We can state at once that the uncertainty in discharge, as caused by ignorance concerning n, will be about 8%, and in required slope about 16 per cent.

The graphical representation establishing these relations is shown in the accompanying logarithmic diagram, Fig. 1. The roughness corresponding to $n = 0.015$, is taken as the standard for comparison. Any other value could have been taken.

This diagram may be used also to adjust results for some one degree of roughness to any other degree.

The Bazin formula, although simpler in form and with fewer categories of roughness, has not such simple relations between its roughness coefficient and values of V or s. The diagram, Fig. 2, shows this clearly. Bazin's category IIIa is taken as the standard for comparison. The form of the formula used is the one in which it most nearly corresponds to Kutter's, namely:

$$V = \frac{128}{1 + \frac{N}{\sqrt{R}}} \sqrt{Rs} \text{ (ft. sec. units)}$$

This is also the simplest form. The value of the roughness coefficient N is 1.81 times Bazin's γ, and is from 11 to 90 times Kutter's n, where the correspondence of the formulas would lead one to expect N always $=$ 42.6 n. This is the recognized peculiarity of Bazin s formula expressed numerically. In all other respects it closely resembles Kutter's as simplified for the usually occurring slopes. Since this is not apparent to many, the comparison is given herewith:

Kutter's formula is

$$V = \frac{(41.6 + 0.0028/s) + 1.811/n}{1 + (41.6 + 0.0028/s)n/\sqrt{R}} \sqrt{Rs}$$

If we give weight to Bazin's opinion that slope has no influence on C, we may place the fraction $0.0028/s = 1$. If, also, we decide to choose different numerical values than did Kutter for the various categories of roughness, we may replace the fraction $1.811/n$ by 115; that is, calling the value of n in this term a medium value, 0.0157. This gives for the complicated fraction the simpler one,

$$\frac{158}{1 + 42.6\, n/\sqrt{R}}$$

in which n is to have values smaller than the Kutter values for smooth channels and larger for rough channels.

While not desiring to champion Kutter's formula as the superior one, I would point out the desirability of giving such numerical value to the coefficient of roughness as to have a simple relation between the retarding influence and the effect. Ganguillet and Kutter have done this, although in other respects their formula is capable of improvement.

It is not intended here to intimate that either of the formulas above discussed is preferable to the formulas with odd decimal exponents, which have been proposed, but have not become widely established as yet.

Effect of Sea-Water on Reinforced Concrete*

By V. I. P. de BLOCQ van KUFFELER

REINFORCED concrete has a sufficient margin of safety in our country for maritime work, but the following points should be most strictly adhered to:

1. Artificial (slow-setting portland) cement of first-class quality and hardening

*Abstract of address before the International Society for Testing Materials, Sept. 1912.

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very uniformly, should be used to the exclusion of all other.

2. The mixing of the materials and the ramming of the concrete in strong and tight casings must be performed with the greatest possible care.

3. The use of trass (or puzzolanes) is recommended.

4. The concrete must be compact and the composition of the mortar should not be below 1 cement, ½ trass, and 3 sand; or 1 cement, 1½ sand.

5. Allowing the concrete to set in a damp atmosphere before placing greatly increases its resistance to sea-water and is recommended wherever possible. When the concrete is exposed to the infiltration of sea-water immediately after manufacture, its composition should be richer.

In conclusion, a carefully considered composition, most careful manufacture, the use of excellent cement with trass (or puzzolanes), and hardening in a damp atmosphere, are the most efficient means of satisfactorily insuring the preservation of reinforced concrete in maritime works.

Electrolytic Action on Unreinforced Concrete*

By CYRIL de WYRALL

ABOUT five years ago I noticed the effect of electrolysis on column bolts imbedded in concrete piers. It was evident that the concrete surrounding the bolts had become disintegrated, so much so in some cases as to render it almost useless, and the effect was greatly intensified where the piers were wet. In view of this, I became interested in knowing what would happen to plain concrete if it were wet and had an electric current passing through it which could escape into the earth.

Four years ago an inspection was made of a 3-ft. concrete wall, erected in 1902, which carried no load and was made of 1: 2: 4 mixture of cement, sand, and trap rock. The examination showed a disintegration to such an extent that the surface was practically mud. Since that time examinations have disclosed still further serious deterioration and a voltmeter test showed that current under 11 volts pressure was passing through this structure. It was believed at the time of the second examination that the 'failure' was due to the action of salt water alone, and no test was made for stray electrical currents until lately.

This is not an isolated case. There is an exact duplicate in almost every particular, except that the latter structure was erected a year later and different brands of cement were used. In the summer of 1911 I made an inspection of some concrete tunnels and bridges on which work has been only recently finished. In all this work the different brands of cement used were rigidly tested. The structures are all above tide-level, and wet only in spots. Where the concrete is wet, from one to five volts was found, and the concrete is deteriorating, though not as much as in the former instances. Where the concrete is dry no voltage was found and the concrete is in excellent shape; this occurs in the same tunnel, the concrete apparently being the same mixture and placed at the same time. It seems to make no difference whether the concrete was placed in cold or warm weather, deterioration goes on just the same, the only difference being between the wet and dry places.

It is a known fact that, although wet concrete is an excellent conductor, dry concrete is practically a non-conductor. The combination of electric current and water seems to act as a disintegrating agent on the cement, destroying its cohesion and reducing it to a paste, which when dried can be pulverized with the fingers. This condition demands immediate remedial measures, or serious trouble will undoubtedly ensue.

One efficient means of preventing the damage may be mentioned, however: waterproofing thoroughly all parts of a concrete structure that is surrounded by earth. Such protection acts in two ways; it keeps the structure dry and it insulates against electric currents.

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Modern Street Railway Track Construction*

By A. C. POLK

INCREASING demands made on various traction companies throughout the country to provide good service made the matter of securing a permanent roadbed in the busy and paved sections of a city a serious problem. Work poorly done originally, and not on a proper foundation, increases the cost of maintenance, cracks and ruins the paving along the poor roadbed by the movement of the track. Unfavorable public comment arises, and the company finds itself face to face with either the entire rebuilding of the roadbed or the attempt to surface and repair the old one. Either alternative is expensive, as the work must be done on a busy street, which interferes with car schedules, with consequent loss of revenue to the company and inconvenience to the public. Therefore, when the paving is done originally, the permanent roadbed should be substantial and effective.

In this paper I am giving a general description of the methods and materials used at Springfield, Missouri, in rebuilding the Springfield Traction Co.'s lines on streets which were being paved by the city during 1911. The company's franchise stipulates that it shall pave the space between its rails and for 2 ft. outside of the rails, while the city paves on the various streets occupied. The work was done by the company, under my supervision, and aggregated more than three miles of new tracks. It was desired to secure as permanent a roadbed as possible; in fact, one which would outwear the rail itself and allow its replacement without disturbing the roadbed if so desired. The illustration shows the general cross-section and detail of the work as put in.

The general features of the structure were a 7-in., 70-lb. T-rail section, 62 ft. long, laid on steel ties. Directly under each rail were longitudinal concrete beams, each reinforced with two ½-in. twisted steel rods, and a 5-in. concrete mat over the beams and the centre of the tracks for a paving foundation. In this case the city contractors were allowed to place the street pavement first, except where it was of asphalt. After the paving on each side of the track had been completed, the old track was moved to one side or the other on the completed pavement, and excavation between the tracks was commenced.

The standard depth below the finished pavement to which the general excavation was made over the whole 9-ft. space was 10 inches. Then two trenches were excavated to exact dimensions, a depth of 9 in. more, and running with the rail. At the joints these trenches were connected by cross-trenches, 30 in. wide, at an additional depth of 3 in., so that each joint tie would be thoroughly embedded and have a good thickness of concrete under it. Around each intermediate tie, shallow trenches were excavated so that there would be at least 2 in. of concrete under the tie and 4 in. around its sides.

All ties were punched on the proper gauge to take 7-in., 70 or 80-lb. T-rails, but the 70-lb. rail was used principally. There were two types of ties, one under the joints which came opposite one another, and the other intermediate between them. The joint tie was an I-beam section, weighing 20 lb. per foot, 6 ft. 8 in. long, having an 8½-in. top, on which the joint rested, and a 4½-in. base. The intermediate ties were of the same length, but weighed 14.5 lb. per foot, and had a 6-in. top and a 4-in. base. All ties were spaced 5 ft. apart, or as near that as the distance between joints would permit.

The rail was fastened to the tie by special lugs and T-headed bolts with square shoulders next to the head. These bolts could be inserted from the top, if so desired, being dropped through the rectangular hole punched in the tie, turned, and then raised until the square shoulder fitted into the rectangular hole, which prevented it from turning while running down the nuts. The lug had a projection on its under side which also fitted into the rectangular hole and prevented it from turning or backing off the rail. A socket wrench was used to run down these bolts rapidly. The joint ties were heavier and wider than the intermediate ones, as noted above, and were punched to allow the lug to fasten over the

*Abstract from *Proc.* Am. Soc. Civ. Eng., August 1912.

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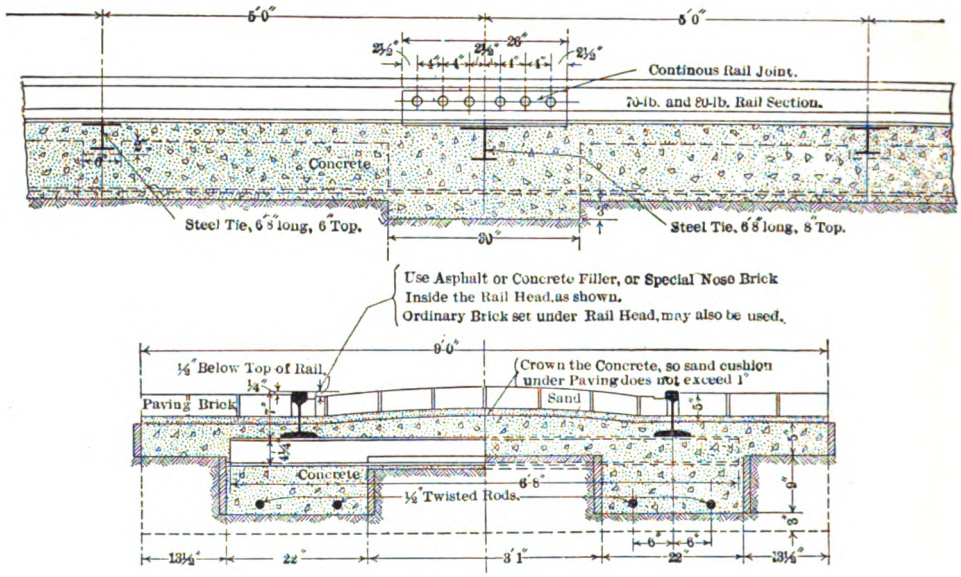
continuous joint which was used. Six-bolt continuous joints were used, and the following method of making them was adhered to with greatest care, as the joint is generally the weak part of the track work:

First, the parts of the rail with which the joint came in contact were carefully cleaned and polished with files and emery cloth until all scale, rust, and particles of dirt were removed and the surface was bright. Then the parts of the joints which came in contact with the rail received the same treatment. Then all contact-parts were greased and the joint put on. The tightening of the bolts was started from the centre working out toward the ends, pulling up a bolt on one side of the centre and then the corresponding bolt on the other side, and when the bolts were all apparently tight a heavy sledge was held against the bottom of the joint on one side and the other side tapped briskly with a light sledge at the bottom only, and *vice versa*. Then the tightening process was repeated until nothing more could be gotten out of the bolts by one man with a wrench having a 30-in. handle. After a continuous joint has once been carefully made in this manner it is there to stay, and even if the bolts were removed the joint would remain under traffic for a long period without any sign of loosening. Another feature in making a joint of this type in this manner is that no bonds were used, or considered necessary. The net area in contact has a far greater current-carrying capacity than the No. 0000 copper bond generally used on heavy lines, and a test showed no trouble with return circuits. It has also been brought to my attention that a section of track put down in a similar manner showed a first-class negative return circuit after two years under traffic.

The track, having been put together as described, was supported on small piers of old brick placed under every other tie and centring under the rail. The final surfacing was done with oak wedges on top of these piers, and both the piers and wedges were concreted in. Two 1½-in. twisted steel rods were placed in the bottoms of the trenches about 6 in. apart. These also were supported at intervals on top of a brick which held them about 2½ in. off the ground. Two extra 4-ft. lengths of these steel rods were placed under each joint to give additional strength at this point, which is usually considered the weak spot of track construction. The track was then given its first surfacing raise, being brought approximately to grade. Afterward, a second finishing surface and true grade was secured by driving up the



SECTION CONCRETE-STEEL TIE TRACK CONSTRUCTION.

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oak wedges. This final surface, however, was only kept a short distance ahead of the mixer on account of the difficulty in keeping the skeleton track in correct line, variations in temperature kinking it.

Concreting was next started, two types of mixers being used on this particular work at different times: One was mounted on car trucks and driven with a 10-hp. motor. It occupied the temporary old tracks which had been previously placed at one side, and was supplied by a regular work-train which delivered the concrete material on flat cars. The other type was mounted on wide-tired wheels, driven with a 15-hp., 500-volt, D.C. motor, and was equipped with a charging bucket. All materials for the latter were hauled in wagons to the streets and dumped ahead of the mixer in such manner that they were about in the right proportions. These materials were cleaned up as the mixer progressed. Of the two methods, the latter was found to be by far the more satisfactory, as there were frequent delays in the delivery of materials to the first mixer by the work-train, and the temporary track was blocked for traffic beyond the point where concreting was in progress, and, on single-track work, passengers had to transfer around the obstruction.

In the second method all material could be delivered on the street for a considerable distance ahead of the mixer, and there was no reason for the mixer to be idle at any time on this account.

The concrete was composed of 1½-in. (maximum size) crushed limestone, Kaw river sand, and chats from the Aurora zinc mine district, the proportions being 1 of crushed stone, 2 of sand, 2 of chats, and 3 of cement, this making a very good mixture. The concrete was mixed very wet, dumped into movable chutes from the mixer, and deposited directly by them on the track. Great care was taken at all times to keep all loose material in the excavation cleaned up ahead of the concrete and to maintain the twisted steel rods in their proper positions. The concrete was puddled carefully under and around all ties with shovels and finally crowned, when it reached grade, with a special board or templet made for the purpose. When the material through which excavation had been made was very loose, or if bad weather had caved in the sides of the trench, forms were placed where necessary to hold the concrete to the exact dimensions of the roadbed. After the concrete had set for 8 hours, and in the majority of cases longer, the brick paving was done.

The paving consisted of first-class paving-blocks, laid on a 1-in. sand cushion, and grouted. The method of laying differed somewhat from the usual practice. Along each rail, and snug up against it, was laid a 2 by 4-in. piece of timber. A stretcher-course of bricks was then laid against it paralleling the rail. The headers across the tracks were then laid and all the bricks were thoroughly rolled and rammed. Before grouting, the 2 by 4-in. piece was removed and the space thus left was filled with concrete to a plane 1 in. below the top of the rail, forming the flangeway for the wheels. After this had set, the whole pavement was grouted thoroughly and carefully. When filled up, the grout remaining over the top of the pavement was allowed to stand until it had attained a set and was fairly stiff, then dry sand was sprinkled over it and the whole was swept thoroughly with wire brooms, thus removing all surplus grout sticking to the tops of the bricks and presenting a very neat clean surface. It was noticeable, too, how very much the work of the paving contractor improved when the requirement of cleaning off the top of the brickwork was strictly enforced. By this method all irregularities of laying and surfacing are strongly brought out, and easily seen and corrected.

The cost of this type of track construction for paved streets, including the paving between and for 2 ft. outside of the rails, using the 70-lb. high T-rail, under the conditions at Springfield, was approximately $5 per foot of single track. This cost may seem to be high, but when the permanent character of the work is taken into consideration, and the cost of doing street work under other methods is analyzed and compared, it will be found to be very reasonable. It possesses several advantages over some of the methods in vogue. It takes less concrete than the old method of filling under and around wooden ties; it places the concrete and the strength where it is most needed, and, when properly put in, it is certainly permanent, and the roadbed will easily outwear two or more sets of rails under heavy traffic. The rail can be changed without disturbing the road in the least, if proper provisions have been made in the

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steel ties originally. On one section of similar track construction known to me, not the slightest sign of any motion could be detected after three years operation, and it is reported to be in as good condition as the day it was built. The work was done by the Springfield Traction Co., owned and operated by the Federal Light & Traction Co. of New York, and under the general direction of W. A. Haller, chief engineer, while I was in full charge of all construction matters at Springfield, Missouri.

Recent Improvements in Street Pavements*

By G. W. TILLSON

STREET pavements is a subject which has been considered for many years—in fact, I may say many centuries. Still there is much to learn. The first pavements were made of rough, large, unformed stones, simply to make a footing. These were gradually improved in size and shape, so that in a few years they were better—better made and better laid. As time progressed, oblong blocks came into use and were succeeded to a certain extent by asphalt, wood, and brick, until at the present time we have four standard kinds of pavements in use, namely, bituminous pavements, consisting of sheet asphalt, asphalt block, and the bitulithic; stone pavements consisting principally of granite and the harder sandstones; wood; and brick.

Although these pavements came into use gradually and by evolution, it was not a short and easy task, for the advance has been made through a long line of experiments with asphalt, brick, coal-tar, cement, iron, iron-slag, india-rubber, shells, stone, leather, and even glass and hay.

The pavements considered standard today are bituminous, wood, brick, and stone. Asphalt is a cementing material which binds the sand together in the same way that portland cement binds the stone to make a cement mortar. The first asphalt pavements in this country were laid in about 1871, although the first ones of any magnitude were laid in 1877 on Pennsylvania avenue in Washington. The first mixture was about 10% of asphalt, or rather of bitumen, and 10% of stone-dust (which was put in to make the mixture dense, so that it would not absorb water, and so that it would give extra wear), and 80% sand. The surface was 2 in. thick and was laid on what was called a cushion coat. This cushion coat was laid ½ in. thick on the concrete and then rolled, and the 2-in. asphalt surface laid upon that. It was found that the material laid as hot as it was—at a temperature of probably 250°F.—when the concrete was damp, would cause steam to arise and make bubbles under the cushion's coat, and raise it from the concrete, so that after the paving was laid a certain length of time, it would slide; then with the cushion coat rolled down smooth and hard, it was difficult to make the wearing surface stick.

So it was decided to lay what was known as a binder coat, formed of stone ranging from 1 in. down to ¼ in. diameter, mixed with about 7% asphalt. The idea was not to have a dense mixture to fill the voids of the stone, but to leave them open, so that when the wearing surface was laid upon it, it would, when rolled, fill the voids in the stone. After asphalt paving had been laid in this way on streets of heavy traffic, it was found that the traffic, which sometimes is as much as 1200 or 1500 lb. per inch on the tire, would drive the wearing surface down into the voids of the binder farther than the roller, and consequently make the pavement uneven and cause the water to collect and occasion undue wear. In order to get away from the trouble within the last few years there has been used what is known as the 'close binder.' That is, the asphalt as it is mixed with the broken stone is also mixed with sand and stone-dust, so that there is obtained a layer of the binder that has a good wearing surface, but not quite so good as the asphalt. It is one that will not wear down nor com-

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press unduly under heavy traffic. Another change which has been proposed, although used only to a very small extent—in fact, I have not seen it anywhere myself—is to have the concrete finished with a hard, smooth surface, practically like the cement sidewalks, except that it should have no polished surface; then upon this concrete will be painted the asphalt, of a thick mixture, and after it is allowed to cool, the asphalt wearing surface laid directly upon that. The theory is that the 'paint' coat will take a firm hold upon the concrete, and the wearing surface will take a firm hold upon the paint coat, and after the surface is complete there will be one that has no inherent weakness after it has once a firm hold upon the concrete. This, however, is in an experimental stage at the present time. It requires the concrete to be laid almost perfectly. If it is loose on top, the paint coat will not hold, and the concrete must be absolutely dry when the paint coat is applied. If the paint coat will take a firm hold upon the concrete, I see no reason why it should not be successful.

Asphalt is, of course, smooth and slippery. It has been laid in the shape of asphalted blocks. The first ones were laid 5 in. deep and 4 in. wide. Laying 4-in. material instead of 3-in. by the sheet method was very expensive, and the asphalt blocks made at a central plant had to be conveyed entire to the street where they were to be used, and this made the transportation scheme expensive. In almost every locality sand can be found within a reasonable distance from the plant, so that the transportation cost, as in the case of concrete, will be small, and it will be necessary to pay for extreme transportation for only 10% of the pavement. In order to reduce the cost, the blocks have been reduced from 5 in. to 4 in. and then to 3 in. and even 2 in. The 2-in. blocks have been laid for two or three years in non-residential streets. Theoretically, the asphalt blocks should wear much longer than the sheet asphalt, because they have an absolutely uniform density and can stand a much heavier pressure than can be exerted by any roller on the street.

Some ten years ago a gentleman who was connected with the asphalt industry conceived the idea of improving macadam pavements by adding coal-tar to the stone, and finally he elaborated his work to such an extent that he mixed the coal-tar with the stone, which was graduated to such a degree that the voids were reduced to about 20%, and a pavement was evolved which was called the 'bitulithic' pavement, and which is considered standard at the present time. The bituminous material in this pavement is generally coal-tar, although asphalt is sometimes used. It has one advantage over asphalt, that, being made of coarse stone, ranging from 1½ in. downward, it can be laid on steeper grades than finer mixtures, as it is not slippery. In Pawtucket, R. I., it is said that it has been successfully used on grades of 8 to 12 per cent.

Brick paving is laid on a concrete foundation, as a general rule. The National Paving Brick Manufacturers' Association contends very strongly that brick pavement should always be laid on a 2-in. cushion of sand placed on the concrete. Most engineers, however, differ from this, and think that a 1½ or even a 1-in. cushion is sufficient if the concrete is smooth. Some of the early pavements were laid with so-called second-class brick as a foundation, placed flat, covered with sand, and the wearing brick laid upon the sand cushion. This was done for the sake of economy, although at the present time the National Brick Manufacturers' Association advocates a method something like this, excepting that they use the largest size bricks and grout the joints, claiming this makes a better foundation than the concrete. The principal consideration is the filler for the joints. The other fillers used are bituminous material and sand. The objection to the sand is that it does not protect the edges of the brick. The bituminous filler is better, as it prevents the pavement from being a continuous whole and prevents it from giving forth a rumbling sound, such as one hears when a loaded truck is driven over a brick pavement when the joints are filled with cement. There is no question, however, in my mind, that if one gets a good cement grout joint one will get a better wearing pavement than in any other way, but there is an objection to its being one slab, as you might say, and also the difficulty of opening it up and repairing in case of making cuts. The brick pavement laid with the cement joint has a tendency to swell up and buckle. Under present methods of construction it does not occur as much as it used to, as the

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pavement is provided with expansion joints filled with bituminous material which takes up the expansion to a certain degree. It is difficult to see why any material which has been heated up to 1800 or 2000°F. should cause trouble by expansion on a street surface, but, as a matter of fact, there have been cases where pavements have exploded with a loud noise. I know of two blocks of pavement that were laid several years ago, where there was a rumbling noise like that made by driving over a wooden bridge. We took some of it up and could find no cavities, and although a space was cut out along the curb, no relief was obtained; it seemed as if there was one immense brick plank lying on top of the sand. After it had been down two years, it was taken up and relaid with asphalt joints.

There has probably been less change in the construction of stone pavements since they first began to be used in the oblong form, although they have probably required it more than any other pavement. Those of us who have lived in this country and have never had an opportunity of looking at the paving abroad have heard that the stone pavements of Europe are much superior to those of this country. I do not doubt that this is true. In Europe the blocks are made better, smaller, and more even, and in many cases they are dressed on the tops and sides. In this country the great item of cost is labor. Our granite-cutters are paid by the piece. They make perhaps $5 a day, whereas the European cutters make only about $1.50, and are content with that. So in making any material change in the block you add materially to the cost of the paving, and before we get our streets in the condition they should be, we must make this change and pay what is necessary to get it. Such pavements as we have been laying cost about $3.30 per square yard, including the foundation. The specifications say that the blocks shall be 8 to 12 in. long, from 3½ to 4 in. wide, and from 7 to 8 in. deep, and should be laid with a ¾-in. joint filled with gravel, which shall range from ¼ in. up to the size that would go into the joint, and the spaces between the gravel shall be filled with a preparation made of coal-tar, pitch, or asphalt.

Last year, in order to get an idea of the European specifications, the Bureau of Paving of Manhattan advertised for granite blocks on Lafayette street, the blocks to be made according to the Liverpool specifications, and also that a certain portion of them should be blocks of the character used in Liverpool. There were three sections in this line of paving: one required 4-in. cubes imported from England or Scotland; another 4-in. blocks of American granite; and another smaller blocks made according to Liverpool specifications, 6 by 4 in. and 6 in. deep. The lowest bid received for that pavement was $4.50 per square yard, not including foundation; with the foundation it would have cost about $5.30 or $5.40 per square yard. Two years ago the engineers of the different boroughs of New York and some of the engineers of the neighboring cities met the granite producers to see how good a block could be produced at a reasonable price. After a long conference the best that the producers would agree to, without considering what the cost would be, was a block 7 to 12 in. long, 3½ to 4 in. wide, and 5 in. deep, but dressed better than before. The old deep blocks were designed for a foundation of sand, and it was thought, by reducing the depth to 5 in., that a block would be obtained which would lay with a ½-in. joint and have no depression on the head greater than ⅜ in.; but the producers of granite blocks felt unable to furnish such a block within a reasonable time and in large quantities. The producers also stated that twenty years ago, when the use of asphalt came into vogue, granite then was not used to so great an extent; most of the granite-cutters, who were mainly old countrymen, went home, and there are no workmen here.

With a smaller stone and smaller joints you cannot use the coarse gravel, but with the ½-in. joint we use a gravel that will fill the joints and the pitch and asphalt. In some cities a portland cement filling is used. The grout is mixed 1:1, applied rather thin, and broomed into the joints after the blocks have been rammed. Additional brooming is done until the joints are filled. The Newark specifications required the surface to be swept until the paving was absolutely smooth on top—made so by the grouting—and in order to do this the street must be kept free from traffic for seven days.

A street laid with granite blocks and the joints filled wth cement grout is, so far as use is concerned, as smooth as an asphalt

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pavement. I examined one, two or three days ago, and was rather surprised to find that, at intervals of perhaps every 100 ft., there were cracks along the street caused by cold weather. I do not think that, so far as wear is concerned, they will do any harm. There was possibly a stretch of 2000 ft., in which there were absolutely no joints to provide for slippage.

The most recent paving we have is the wood block as it is laid today. The first wood blocks in this country were laid in the forties in Philadelphia, New York, and Boston. They were made of any kind of wood, and laid in almost any kind of way, and correspondingly lasted only a short time. Then little or nothing was heard of wood paving for about twenty years. It is singular that paving fads seem to run in cycles of about twenty years, for about twenty years later there came up the Nicholson block, which was a creosoted pine block laid on a plank foundation with concrete between; it made a first-class pavement for a year or two, but soon the blocks began to decay irregularly, and the result was decidedly bad. In practice, this pavement cost as high as $4 to $5 a square yard, and when asphalt began to come in, it was sometimes laid on top of this wood-block paving. Only last year we took up an asphalt pavement that had as a foundation wood that was laid over twenty-five years ago. Still, twenty years afterward there came up the cedar-block craze through the West, and it was much in evidence where real estate booms were on and ambitious towns wanted a pavement quickly. Chicago at one time had 700 miles of it. It cost 70 or 80 cents a square yard, and lasted only four or five years. About twenty years after that some people in Des Moines thought that if they laid good pavements of wood in the old country they could do the same thing here, and they tried treating the wood blocks with creosote. The first blocks treated had an uncertain quality of oil and an uncertain quality of wood, but the general results were good. This process was followed by treating the blocks with a creosote-resin solution, made of equal parts of creosote oil and resin. There were no requirements in the early specifications as to the character of the oil, and I think the first pavements of that character under general specifications open to the public were laid in Brooklyn in 1903. A street was paved with wood in 1902, the city prepared the foundation, and the contractor furnished the blocks and laid them for nothing, as an illustration of what the pavement was. The pavement today is in practically as good condition as when it was first laid.

In preparing our specifications the question was put up to me, "How do you know our pavement is going to have this treatment?" We did not wish to have an inspector to inspect the blocks, and decided to have an absorption test and a specific gravity test for the block as follows: The block was dried for 24 hours at a temperature of 120°F.; it then should not absorb more than 3% of water after being immersed in water for 24 hours, and it was also provided that all blocks should sink when put in water. We let quite a number of contracts under these specifications, with no expansion joints, and have had almost no trouble. We have some streets that have been down some seven or eight years, and have had absolutely no trouble with them. I stated that the composition used was creosote oil and resin. We did not want to make a specification that would be an absolute monopoly, and although we did not think that more than one man would bid, we made the specification "creosote and resin, or some other suitable material." However, a new contractor turned up as the lowest bidder, and he did not use resin, and my chemist had several weeks wrestling with the analyses and the oils before he could determine if the material was suitable waterproofing material; as near as he could tell, it was pitch, but we finally decided it was a suitable waterproofing material and accepted the contract, and the blocks were shipped. Another point is that wooden blocks require a certain amount of traffic to keep the blocks matted down and to prevent any moisture getting into the blocks and softening them up.

There are quite a number of moot points in the manufacture of wood-block pavement, but the principal question is the character of the wood; then the cushion for the blocks, and the character and quantity of treatment. Now I think there is no question that the best material for the pavement itself is hard pine, long-leaf yellow pine, although that perhaps is not necessary in a residential street. It is hardly possible for a street such as we have in Brooklyn to wear out,

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but it must have a certain amount of traffic to keep it down. The only material that we have used to any extent is the black gum. The Government is making an elaborate set of experiments to determine not only what is the best wood, but what are some of the cheaper woods that can be used for paving purposes and give satisfactory results, as the hard pine is becoming more and more dear, as well as the cost of laying. I think it absolutely safe to use the hard pine. And now it comes to the question of the cushion. The original pavements laid in Brooklyn had a cushion of cement mortar of 1:4 mixed as dry as it could be. If it was too soft, the heavy blocks would settle in it, and an even surface could not be obtained. We did, however, get an even surface with the wood blocks laid on that cushion. I think the cement cushion is better than the sand cushion.

Then there is also the question of the filling in the joints, which sometimes are filled with sand, sometimes with cement grout, and sometimes with pitch. When there is any traffic in the Brooklyn streets you hardly see any joint at all. We want fine sand so that the joints will be filled, and it seems to me that with this pavement you get a satisfactory pavement. I do not know but the benefit of not bulging in wet weather is due to having the sand joint. Some people of the West are using the bituminous filler, but, as often happens, the blocks bleed, and the pitch in the joints simply adds to the trouble and makes the nuisance greater. If a bituminous filler is used, it acts as an expansion joint, and there should not be so much bulging with the bituminous filler joint as with other fillers.

TABLE SHOWING PROPERTIES OF A PERFECT PAVEMENT AND PERCENTAGES ASSIGNED TO THE DIFFERENT STANDARD PAVEMENTS.

	Per Cent...	Granite....	Wood.....	Asphalt....	Brick.....
1. Cheapness	14	8	8	14	11
2. Durability	21	21	16	15	16
3. Ease of cleaning.	15	10	14	14	15
4. Load resistance to traffic	15	13	14	12	15
5. Non-slipperiness..	7	7	4	5	6
6. Ease of maintenance	10	10	8	6	6
7. Favorableness to travel	5	2	5	4	3
8. Sanitariness	13	9	13	12	10
Total	100	80	82	82	82
Less cheapness... ..		72	74	68	71

Bitulithic is assumed to be about the same as asphalt.

Electric Propulsion Equipment of the United States Collier 'Jupiter'*

IN July 1911 the U. S. Government closed a contract for the equipment of the naval collier *Jupiter* with a system of electric propelling machinery proposed and designed by W. L. R. Emmet, of the General Electric Co., Schenectady, New York.

The *Jupiter* is a sister ship to the twin-screw colliers *Neptune* and *Cyclops*, the former having a turbine connected to each propeller through a mechanical gear held in a floating frame. The *Cyclops* has two triple-expansion engines. These vessels have a displacement of about 20,000 tons, carry 12,000 tons cargo, and are designed to operate at 14 knots. The principal data concerning the equipment of these three vessels is summarized in the accompanying table.

The electrical installation proposed for this collier is similar in general scheme to that proposed for battleships, but much simpler. The requirements of the collier are to operate continuously for long periods at a speed near the maximum, so there is no particular need for high economy at low speed. It then becomes desirable to simplify the equipment as much as possible consistent with good economy at the normal operating speed, 14 knots. Therefore, only one generating unit and two motors are used. For comparison, in a battleship two generating units and four motors would be provided.

*Abstract from *Engineering News*, September 12, 1912.

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	Cyclops.	*Jupiter.*	*Neptune.*
Displacement, tons	20,000	20,000	20,000
Indicated hp. at 14 knots	5,600	.....	.....
Engine or turbine r.p.m. at 14 knots	88	2,000	1,250
Propeller r.p.m. at 14 knots	88	110	135
Weight driving machinery, tons	280	156	.....
Character of driving machinery	2 triple-expansion engines	1 turbo-generator and 2 motors	2 turbines each with gearing
Steam consumption, lb. per shaft hp.-hr.	14 (est.)	12 (tested)	

so that economy would be secured at all speeds by operating for the lower speed with one-half of the apparatus in use. In the contract for the collier *Jupiter* the manufacturers had to guarantee under penalty the time delivery, the water rate per shaft horsepower at 10 and 14 knots, and also that the weight of the electrical equipment would not exceed that of engines proposed for the ship. In case the machinery was rejected due to failure to meet contract requirements, all the apparatus was to be removed by the manufacturer so that the Government might install the engines which were originally intended. Therefore, the electrical machinery was made to conform in outline to the engine layout, which was possible with room to spare.

All of the apparatus was built and tested at the shop previous to shipping for installation. The test results indicated that all guarantees were met with a large margin. The water rates at 14 and 10 knots are, respectively, 12 and 14.2 lb. per b.hp-hr., which is about 1 lb. better than the guarantee. The actual weight of equipment is 156 tons, a saving of about 40% over the reciprocating engine proposed. The main generating unit is a 6-stage Curtis turbine driving a bi-polar alternating-current generator. At 14 knots, the speed of the unit is about 2000 r.p.m. and the voltage about 2200. The turbine was designed to be especially accessible; new buckets can be attached to any of the wheels by simply removing the top half of the casing. Any one of the six stages will run the ship at about half speed, so that the loss of one or more stages will not entirely disable the vessel.

The generator is a 5450-kv.-a. 2300-volt machine with a solid forged field (rotor) spider with a distributed field winding of copper strips insulated with asbestos and mica, being absolutely fireproof. The end windings are held in place by a one-piece nickel-steel ring, on the outer end of which is mounted a fan which draws air in from the bottom of the machine through the air gap, and forces it through the stator air-ducts to the top of the generator, where it is led away. The armature (stator) is wound for 2300 volts with a regular bar winding (Y-connection) each slot having two bars insulated with mica and asbestos. The core is of laminated silicon steel. At first thought, this voltage will seem high to many for use on shipboard, but it has been selected by the designer as being the most convenient and economical one in the design and operation of the equipment. With apparatus of this size, voltages of 2000 to 3000 give very simple windings and yet with no possible insulation troubles. The conductors are of reasonable size and the connections simple and direct; the cables carrying currents from the generator to the motors are of moderate size and the small currents bring only small self-induction. The switching devices are light and easily handled without danger of burning the contacts or other difficulties which are sometimes involved in the switching of very large currents. The windings of the generators and motors are entirely closed and the circuits are only a few feet long and entirely concealed, so that there is no possibility of danger to persons operating the apparatus. With apparatus of similar size and voltage, insulated in a similar manner, there has hardly been a case of insulation failure in the 15 years' experience of the manufacturer. As the alternating-current apparatus is connected to no extensive transmission or distribution systems, there can be no high-frequency disturbances of the kind ordinarily met with, and the arrangement of the machinery is such that there be no heavy rushes of current.

The generator delivers current to two

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motors, each a 2750-hp., 110-r.p.m., 2300-volt, 36-pole type. The motors are directly connected to a propeller shaft. They have wound rotors and slip rings for inserting external resistance into the rotor circuit. Each motor is framed entirely of steel; the stator spider is a casting subdivided into four sections. Silicon steel is used in the core laminations. The stator has two coils per slot, formed of rectangular conductors insulated with mica and tape, and varnished to render them waterproof. The rotor is wound with two bars per slot, the insulation being similar to that of the stator. The ratio of synchronous speed reduction between generator and motors is 18 to 1, the propeller turning at 110 r.p.m. for a ship's speed of 14 knots per hour.

The external resistance is connected in series with the rotor circuits during the process of reversing, and also when maneuvering the boat. For straight running the rings are short-circuited by a slider on the motor shaft, operated by a lever attached to the frame of the motor. The resistances are made up of grids of non-corrosive metal mounted in series on an insulating barrel through which sea water is pumped in straight contact with the resistance grids. This amounts to grounding the neutral of the motor-secondary circuit.

The generating unit and motors are self-lubricating and self-ventilating. Sheet-metal ducts will be connected to their air outlets in such a manner that the heated air will be led to the suction of the fire-room blowers and so will not be released in the engine room to raise the temperature there.

Although the generator is of special design, with rather high armature reaction and relatively low ampere turns per pole so that the short-circuit current is small, additional mechanical or electrical interlocks have been provided in order to prevent the closing or opening of wrong switches. Thus, it is impossible to close the 'ahead' switch if the 'astern' switch is closed, and neither switch can be closed without the resistance being in series with the motor armature for starting. Magnetic locks, energized by the field circuit of the generator, are attached to the levers which insert and cut out the resistance. These locks prevent the movement of these levers until the generator has lost its field, thus preventing any possibility of burning contacts by switching at the wrong time or improperly. This involves momentary cessation of power input. While the apparatus is designed to sustain the loads due to short circuiting the resistance, yet the intermediate step was thought desirable for a time at least.

There are two distinct operations of the control equipment for operating the ship. The first is the maneuvering position, in which the resistances are continuously in the circuit of the motor rotors. Thus connected, the motors can be started, stopped, or reversed practically instantly by simply opening or closing the proper switches, while the boat can be run at any speed up to about 9 knots. In the second position, which is the normal running position, the motors are run without resistance in the armature circuit; the change in the speed of motors necessary for changing the speed of the vessel is secured by varying the speed of the generating unit, the ratio of speed reduction remaining practically fixed at 18 to 1. This change of generating-unit speed is not made by throttling, as is usual with ship turbines. Instead, the turbine is equipped with a governor of novel construction arranged to hold the speed at any desired point from about 5 knots up to 14, the maximum. The voltage and frequency of the current varies directly as the speed of the main unit. Thus the frequency varies from 15 to 33 and the voltage from 1100 to 2200 voltage and frequency varying together.

In the shop tests of this equipment previous to shipment for installation, the two motors were set up in the factory, the turbine connected to a condenser, and one motor installed in the same position relative to the switch-controlling mechanism that would occupy on board ship. The other motor was run as a second generator and was mechanically coupled to the first motor as a load, in place of a propeller. By this loading-back arrangement it was possible to test the motor for all conditions under which it might operate on board ship and to show the ease with which it could be started, stopped, and reversed. The water rates of the turbo-generator unit were taken under the exact conditions of operation, namely, 190 lb. steam gauge with 28½-in. vacuum, the generator being loaded on a water resistance in the usual way. Price of the electric propelling machinery for the collier *Jupiter* was $13.75 per horse-power.

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Action of Sea Water on Cement*

By Messrs. LOMBARD and DEFORGE

FROM the standpoint of practical construction of maritime works, it may now be regarded as established that while the majority of the binding media in actual use are liable to decomposition, portland cement is the one to be preferred in every respect. For maritime works it is advisable to prepare mortars which are rich in cement and as dense and compact as possible, so as to increase their impermeability.

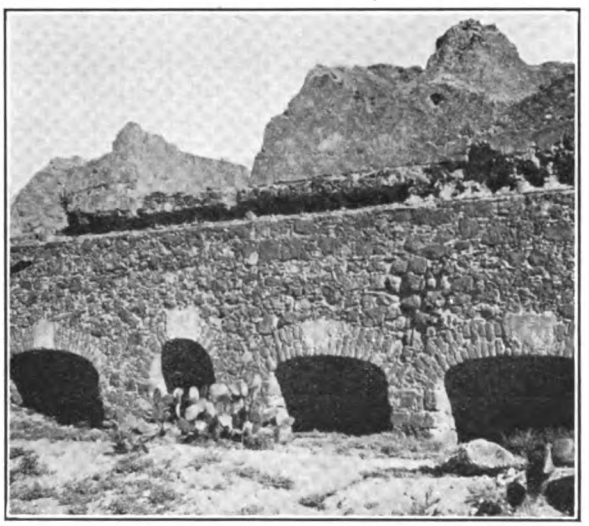
It is advisable not in any case to take less than 500 kg. of cement per cubic metre of sand, a proportion of more than 600 kg. being, moreover, the best from all points of view. In the experiments carried out with 312 blocks, one fact, already noticed in the previous tests, stands out prominently—namely, the bad condition of mortars with less than 450 kg. of cement, and the confirmation of the inferiority of mortars made with fine sand in comparison with those made with coarse sand, especially where the proportions of cement are small.

These observations find direct application in the use of reinforced concrete for maritime works (construction of piers for jetties or revetments for piers or quay walls) for which it is advisable to employ larger proportions of cement than are usual for similar works in fresh water.

Masonry work should be constructed with blocks of the largest practicable dimensions, and the mortar should be mixed to a soft paste, without excess, but nevertheless in sufficient quantity to fill up exactly the spaces between the materials, which latter should be as little porous as possible. Finally, the joints should be made of good mortar, well bonded to the iron.

Some years ago, for reasons of economy, recommendations were made to use facings of cement masonry, with fillings of masonry set in hydraulic lime water. This practice has led to numerous disappointments, and the mortars of many quay walls built on this plan in the Department of Charente Infre during the past twenty years are now in a state of decomposition. The entire mass of the structure of a work should be set in mortar of one kind and quantitative composition, in order to prevent frequent replacement.

*Abstract of address before the International Society for Testing Materials, Sept. 1912.



RUINS OF OLD SPANISH MASONRY IN MEXI CO BEFORE THE DAYS OF PORTLAND CEMENT CONCRETE PERMANENCY.

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Company Reports

San Joaquin Light & Power Corporation increased its surplus after interest for the month 80.65% over July a year ago. The showing for the preceding six months was not so good, for the reason that the company was carrying heavy interest charges for new installation that was not reflected in earnings. But with July this condition was changed, and as a result of new contracts the net income increased 48¼% over July 1911, in spite of reductions in rates in certain portions of the system. The company reports as follows:

	Month ended July 31 1911.	1912.
Gross income	$ 82,344.54	$110,530.72
Operating expenses	39,511.82	47,030.94
Net income	$ 42,832.72	$ 63,499.78
Interest charges	24,168.64	29,781.45
Balance	$ 18,664.08	$ 33,718.33
	Seven months ended July 31	
Gross income	$615,819.84	$743,188.89
Op. exp. and taxes	269,178.58	310,058.25
Net income	$346,641.26	$433,130.64
Interest charges	146,110.11	217,839.00
Balance	$200,531.15	$215,291.64

The Nevada-California Power Co. reports for July:

	1912.	Changes.
Gross	$ 68,800	Inc. $5,248
Net	56,532	Inc. 5,698
Surplus	41,302	Inc. 4,698
Res. for Dep.	8,650	Inc. 400
Net profits	$ 32,652	Inc. $4,298
	From Jan. 1 to July 31	
Gross	$ 481,121	Inc. $40,008
Net	397,751	Inc. 49,484
Surplus	296,302	Inc. 48,245
Res. for Dep.	58,150	Inc. 6,400
Net profits	$ 238,152	Inc. $41,845

Southern California Edison Co. report for the twelve months ended July 31 last, shows liberal gains in gross, net, and surplus earnings, as compared with the previous corresponding year. After meeting all expenses, taxes, and interest charges, there was left a balance surplus amounting to more than $1,300,000, as against about $1,000,000 for the year previous. Therefore, it is apparent that the company earned a surplus over charges equal to about 32¾% on its $4,000,000 outstanding preferred stock, or 11% on its $11,900,000 total outstanding stock, including both preferred and common.

Following are the company's earnings for the twelve months ended July 31:

	1912.	1911.
Gross earnings	$4,146,514	$3,529,040
Op. exp. and taxes	2,098,972	1,771,301
Net earnings	$2,047,542	$1,757,739
Interest charges	739,250	738,000
Surplus	$1,308,292	$1,019,739

Indications now are that the company will earn the largest amount of gross and net on record during the current calendar year. July earnings, as well as those for the seven months ended July 31 last, exhibited liberal increases over the corresponding periods of the previous year. In July the gross expanded about $76,000, and the net improvement was $37,000. For the seven months the gain in gross was about $400,000, while the increase in net, after expenses and taxes, was about $37,000.

Following are the company's earnings and expenses for July, and the seven months ended July 31, in comparison with the corresponding periods of the previous year:

	1912.	1911.
Gross earnings	$378,635	$302,488
Op. exp. and taxes	192,380	153,436
Net earnings	$186,255	$149,052
	From Jan. 1 to July 31:	
Gross earnings	$2,478,397	$2,070,048
Op. exp. and taxes	1,290,605	1,027,518
Net earnings	$1,187,792	$1,042,530

Portland Railway, Light & Power Co. reports for July and seven months as follows:

	1912.	Changes.
Gross	$ 580,557	Inc. $36,853
Net	298,902	Inc. 14,136
Surplus	157,887	Inc. 3,781
	From Jan. 1 to July 31	
Gross	$3,833,174	Inc. $174,658
Net	1,904,182	Inc. 8,740
Surplus	891,991	Dec. 129,967

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Coast Counties Light & Power Co. reports an increase in surplus for the month of 32.39% and for the seven months an increase of 17.17%. The company reports as follows:

	Month ended July 31 1911.	1912.
Gross earnings.....	$26,024.39	$28,373.19
Op. exp. and taxes...	12,556.82	13,172.28
Net earnings	$13,467.57	$15,200.91
Net profit from Un. Tcn. Co.	8,073.32	11,358.24
Net income for int.	$21,540.89	$26,559.15
Bond interest	6,046.70	6,046.70
Surplus	$15,494.19	$20,512.45
	Seven months ended July 31	
Gross earnings.....	$144,455.08	$162,101.18
Op. exp. and taxes....	65,286.30	75,339.44
Net earnings	$ 79,168.78	$ 86,761.74
Net profit from Un. Tcn. Co.	2,661.03	5,365.80
Net income for int.	$ 81,829.81	$ 92,127.54
Bond interest	39,326.66	42,326.70
Surplus	$ 42,503.15	$ 49,800.84

Mount Whitney Power & Electric Co. reports as follows:

	Month of July 1912.	1911.
Gross earnings	$ 39,128	$ 31,785
Operating exp. and taxes.	15,886	12,689
Net earnings	$ 23,242	$ 19,096
Interest on bonds.....	7,875	.....
Other interest	939	.....
Net inc. after charges.	$ 14,428	.....
	Twelve months ended July 31	
	1912.	1911.
Gross earnings	$421,948	$371,288
Operating exp. and taxes.	192,955	150,112
Net earnings	$228,993	$221,176
Interest on bonds.....	80,097	.....
Other interest	72	.....
Net inc. after charges.	$148,824	.....

Net income cannot be compared with 1911, as the company had no fixed charges at that time. Since then it has been paying 6% interest on $350,000 outstanding bonds, and the investment will not be reflected in earnings until this month. The proceeds of the bonds were devoted to the installation of 3500 additional horse-power, and, as markets already exist equal to the capacity of the new plant, the effect of the extension will soon manifest itself in the surplus, as net earnings are showing a steady increase over 1911.

The Denver & Rio Grande Railroad Co. reports for July:

	1912.	Changes.
Total op revenue....	$2,057,138	Inc. $79,522
Op. exp. and taxes..	1,582,628	Inc. 101,834
Operating income..	$ 474,510	Dec. $42,312
Other income	98,480	Inc. 667
Total income	$ 572,990	Dec. $41,645
Fixed ch. and rentals	496,122	Inc. 9,374
Net income	$ 76,868	Dec. $51,019
Renewal fund	10,000	
Surplus	$ 66,868	Dec. $51,019

The same road reports gross revenues as follows:

	1912.	Changes.
Fourth week August.	$ 736,300	Inc. $5,900
Month	2,200,000	Inc. 29,300
From July 1.....	4,230,000	Inc. 98,900

Northern California Power Co., Consolidated, has issued a report for the month of August which shows that the margin of safety for interest is more than 130%, with $10,033.36 applicable to dividends. During the last few months the company has connected up a motor load in its territory of 3618 hp. The statement is as follows:

Gross earnings	$66,023.38
Operating and general exp.....	15,684.32
Net earnings	$50,339.06
Mantenance and depreciation reserve	9,478.08
	$40,860.98
Interest on bonds and debentures.	30,827.62
Available for surp. and div.....	$10,033.36

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Book Reviews

STRENGTH OF MATERIALS. By Mansfield Merriman. 169 pp.; index. John Wiley & Sons, New York. For sale by the *Mining and Scientific Press*, San Francisco, California. Price $1.

This is the sixth edition of Mr. Merriman's elementary text-book on this subject, the first edition having been issued in 1897. It is intended primarily for students having an academic knowledge of mathematics and elementary mechanics, and is especially adapted for use in manual training schools and for home study. Questions of elastic deformation which require a knowledge of calculus are subordinated to those of strength, although the results and effects are stated, so that the student may acquaint himself with their uses in preparation for more advanced study. Many examples for practice are given to aid students in the application of principles involved. A chapter dealing with reinforced concrete was added to the fifth edition, and the entire subject has been amplified and enlarged to bring it up to present-day practice. As a whole, the book is in keeping with the thoroughness and clarity that have made the author's writings a standard in the field of technical literature.

VALUATION OF PUBLIC-SERVICE CORPORATIONS. By Robert H. Whitten. 745 pp.; index. The Banks Law Pub. Co., New York. For sale by the *Mining and Scientific Press*, San Francisco, California. Price $5.50.

The relations between public-service corporations and city, state, and federal officials in the matter of rate-fixing is one of the most interesting phases in the development of modern civilization. A difference of opinion is said to be the element that makes trade. Certainly there is no lack of differences of opinion between the city and corporation officials who come together annually in every large city for the purpose of rate fixing. Mr. Whitten has prepared a valuable work which is practically an encyclopedia on the subject, and has also prepared a complete index and glossary of the various decisions of courts all over the United States that in any way bear upon the subject. The author states that as the entire question is still in a development stage, and as many of the points involved may not receive final authoritative determination for many years, he has included in the text an exceptionally full statement or discussion of the economic principles involved. Such conclusions as have been reached must necessarily be purely tentative, but the logical reasoning of a trained legal mind cannot help but be instructive and enlightening, particularly in view of the fact that Mr. Whitten seems to be without bias or prejudice in favor of either side, but disposed rather to accord fair dealing and justice along the lines of the legal definition of the rights of both property owners and consumers that have already been established. This book will well repay careful study by all of those who are interested in this subject, and will be of great value to such persons as may be called upon to give opinions on the valuation of public-service corporations and rate fixing.

FIRE PREVENTION AND FIRE PROTECTION. By Joseph Kendall Freitag. 1038 pp.; index. John Wiley & Sons, New York. For sale by the *Mining and Scientific Press*, San Francisco, California. Price $4.

> "A little fire is quickly trodden out,
> Which, being suffer'd, rivers cannot quench."

With the horrors of the San Francisco fire fresh in our minds, and with the evidence of its destructive power still visible before us, Shakespeare's words, which form a portion of the author's preface, have a grim significance. An ounce of fire prevention is worth a pound of fighting-apparatus, while the lessons taught by recent conflagrations seem all too soon forgotten in the enthusiasm for rebuilding and the eagerness to recommence the collection of rents. Mr. Freitag's work should be in the hands not only of every architect, civil engineer, and builder, but of every man interested in building construction. The man who holds the purse is primarily responsible for the lack of fire protection, which fact, however, is not always apparent until some great disaster, like the San Francisco, Chicago, or Baltimore fires, discloses the unprotected condition of our cities when it is too late to provide a remedy. The subject is covered in a thorough, comprehensive, and sys-

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tematic manner. While the theory of fire protection is discussed at length in Part 1, the other five parts into which the book is divided are devoted to the actual results shown by practically every known type of construction, fire-protecting devices and methods, forming the most comprehensive and exhaustive presentation of the subject we have ever seen.

The absence of the term 'fireproof' as applied to building construction is noted with pleasure, the substitution of 'fire-resisting' in greater or less degree being more significant and a truthful representation of the facts. Reports made by the various individuals and commissions who made examinations of the great fires in the United States, together with a vast amount of data obtained from lesser conflagrations, has been classified and presented in detail under various captions, a thorough index facilitating ready reference to any branch of the subject. The book itself is of the 'pocket handbook type' and will undoubtedly take its place with Kent, Trautwine, and Haswell as an indispensable adjunct to the practice of the engineering profession.

MAPS OF CALIFORNIA OILFIELDS. Compiled by Weaver-Tiernan Map Co., Los Angeles. 59 pp. For sale by the *Mining and Scientific Press*, San Francisco. Price $12.

Many maps have been published from time to time covering the California oilfields, practically all of which were out of date in one particular or another before they came from the printer's hands. The Weaver-Tiernan Map Co., however, has adopted the modern loose-leaf system and proposes to look upon purchasers of their maps more in the line of subscribers, and announces that it will revise and send new sheets as fast as any changes take place. Each leaf of the maps covers one township, and gives also the last ownership of lands, location, and depth of wells and gushers, in various parts of the township. Routes of the numerous pipe-lines, railroads, and wagon-roads, contour lines taken from the U. S. Geological Survey, charts and indices are also given. By use of diagonal-line shading, each section of such subdivisions as have been withdrawn from entry by the United States Government are shown. The maps are blueprinted on paper with a blueprint cloth binding and from a careful examination it would appear that this method of handling the subject is by far the best that has yet been devised. The publishers of the maps have a field force and other means of keeping in touch with the oil situation, development, changes in ownership, etc., and their maps will undoubtedly prove to be a most valuable reference to anyone interested in the oil industry, whether from an operating, engineering, or speculative standpoint.

HIGHWAY ENGINEERS HAND BOOK. By Wilson G. Harger and Edmund A. Bonney. McGraw Hill Book Co., New York. 493 pp.; index. For sale by the *Mining and Scientific Press*, San Francisco. Price $3.

The unusual activity in the construction of good roads all over the United States in response to the demand created by the great increase in the use of the automobile has brought out what might be termed a new profession, that of highway engineer. Until the last five or six years, comparatively few engineers were experienced in road building, and the organization of the various state highway commissions has called attention to the fact that engineers familiar with the requirements of road building to meet the conditions brought about by the use of the motor car were few and far between. The bibliography of the subject is not only scant, but almost entirely given to discussion of the practice of road building as it existed before the advent of the motor car. The high-speed, gasoline-driven vehicle of today has brought out an entirely new set of conditions which must be observed in designing roads. In providing a thorough and comprehensive handbook dealing with this important subject, the authors have performed a genuine service which will be greatly appreciated by highway engineers. Lack of space prevents giving a complete summary of all of the subjects covered, as the book deals not only with the various types of road construction and the effect of road vehicles upon them, but dwells also upon the various accessories to road building, such as culverts, highway bridges, etc. Contractors' specifications are given at length, as well as many suggestions for office practice, estimates, construction methods, and equipment for maintenance and repair. Considerable space is devoted to cost data, which alone should be worth the price charged for the book.

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Engineering Bonds

*Tax exempt in California.
†Legal investment for savings banks in California.
‡Available as security for deposit of state, county, and municipal funds and postal savings deposits.

COAST VALLEYS GAS & ELECTRIC CO. has issued bonds dated March 1, 1912, and due March 1, 1952, amounting in all to $786,000. These are first-mortgage 6% bonds and are callable at 105 and interest; $2,000,000 preferred stock and $3,000,000 common stock are outstanding in addition to the bonds. Additional bonds to the amount of $214,000 may be issued up to the full value of improvements and extensions of the present property, and the net earnings, after deducting all operating expenses, taxes, and insurance for twelve months preceding are equal to 1¾ times the interest on all bonds then outstanding and those proposed to be issued. The remaining $9,000,000 in bonds may only be issued up to 80% of the cost of further additions and extensions, subject also to the above earnings requirements. In addition to the provisions mentioned above covering the trust deed governing the issuance of escrow bonds, the public utilities act of the state of California, which went into effect on March 31, 1912, requires the approval of the Railway Commission to the issuance of all bonds of this issue over and above the $786,000 now outstanding. The Coast Valleys Gas & Electric Co. owns the entire capital stock of the Monterey & Pacific Grove Railway Co. and exclusively serves the electric and gas business in the towns of Monterey, Salinas, and Pacific Grove, and also owns the water system of Salinas as well as the distribution system in the Salinas valley. Statement of earnings and operating expenses for 1911-12 is as follows:

	Years ended Feb. 28		
	1911.	1912.	*1913.
Gross earnings ...	$149,489	$155,708	$210,000
Op. exp. and taxes.	96,260	78,306	110,200
Net earnings ..	$ 53,229	$ 77,402	$ 99,800
Int. on bonds.....	37,920	37,920	47,160
Surplus	$ 15,309	$ 39,482	$ 52,640

*Estimated.

UNITED RAILROADS has been authorized by the Railroad Commission to issue $365,000 of 6% trust notes, the proceeds to be used for the purchase of street-cars. These notes will be issued as a first lien against new cars for the purchase of which the funds are to be employed.

ATCHISON has issued $147,711,000 convertible bonds. Of these bonds, $69,458,000 have been converted into common stock, as follows:

	Issued.	Converted.	Outstanding.
1905 4s....	$49,711,000	$33,095,000	$16,616,000
1909 4s....	28,258,000	24,672,000	3,586,000
1907 5s....	26,056,000	11,691,000	14,365,000
1910 4s....	43,686,000	.....	43,686,000
Total ..	$147,711,000	$69,458,000	$78,253,000

Outstanding common stock now totals $171,413,500, of an authorized issue of $250,000,000.

If all the bonds were converted, there would be outstanding $249,666,500 common stock, which would require in dividends, at 6%, $14,979,990. Dividend requirements on common now out aggregate $10,284,810, which would mean $4,695,180 more necessary to satisfy stockholders in event of conversion. The conversion privilege on the 1907 issue of 5s expires on May 31, 1913, and there are now $14,365,000 of these bonds unconverted.

With conversion of these bonds into stock, the road would be relieved of interest thereon. This, on all convertible bonds now out, amounts to $3,273,770 annually. Taking this saving into consideration, net addition to Atchison's yearly outlay would mean only $1,421,410 a year, if all the bonds were turned in for stock.

For the year ended June 30, Atchison had a surplus available for common dividends of about $14,500,000. Dividend requirements were about $10,260,000, leaving a balance of over $4,000,000. Add the $1,421,410, which would be the net augmentation if all bonds were converted, and there still would remain a balance of over $2,500,000. All proceeds from the convertible bond sales have gone into improving and strengthening the system, and there is no doubt that under moderately favorable circumstances the benefits from these improvements will be reflected to a greater extent in earnings than they have been so far.—*Boston News Bureau*

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Engineering News

Power, Gas, and Electricity

San Francisco.—The Railroad Commission has authorized the Indian Valley Electric Light & Power Co. to issue 6979 shares of stock and $816,533 in 5% bonds to reimburse O. C. Pratt for money advanced.——The Round Valley Water Co. has announced that it will construct an electric power plant in the vicinity of Seneca, Plumas county, California, for furnishing electricity for power and lighting purposes in that district.——The United Railroads report gross earnings for July $687,013, operating expenses $404,574, net earnings $282,439, a decrease of $11,823 as compared with the corresponding month in 1911.——The Coast Counties Gas & Electric Co. has applied to the Railroad Commission for permission to purchase all the property of the Davenport Light & Power Co. at Marysville.——The Arrowhead Reservoir & Power Co. of San Bernardino has applied to the Railroad Commission for permission to issue bonds in the sum of $4,000,000. The company proposes to construct a dam at the Little Bear valley reservoir site and at Grass Valley reservoir site to develop water for power and irrigation purposes. These extensions will require approximately $2,750,000, the balance of the funds will be used for liquidating existing indebtedness and other purposes. This company owns the Redondo Reservoir & Power Co.——The Great Western Power Co. has applied to the Railroad Commission for permission to purchase the North Sacramento Light & Water Co. for the sum of $9000.——The Pacific Gas & Electric Co. announces that it had 299,350 consumers on June 30, 1912. Their gross earnings for the eight months ended August 31, 1912, were $9,694,841, expenses and taxes $5,464,755, net earnings $4,230,086, interest $2,319,118, surplus $1,910,968. The Railroad Commission has granted permission to the Pacific Gas & Electric Co. to issue $5,000,000 in bonds for improvement in service and equipment in northern California, covering ultimately a total expenditure of $12,282,441.02. The projected improvements include hydro-electric power plants on the south fork of the Yuba river in Nevada county and on the Bear river in Placer county; a power line from the latter station to a point in Solano county opposite Crockett in Contra Costa county; a steam-power station in Sacramento, a duplicate steel tower high tension transmission line from Cordelia to San Rafael. Approximately 40,000 kw. will be added to the company's generating capacity. The appropriation for the Sacramento steam power station is $409,820. A new building and additions to the San Francisco offices will cost $350,000.——It has been announced that the Western Pacific railroad, in connection with the Denver & Rio Grande, has abandoned its project for the electrification of the Rio Grande road over Soldier's Summit in Utah.

Vallejo.—City officials have placed the contract with the Great Western Power Co. for furnishing power for operating pumps at a price of 2c. per kw-hr. for 75,000 kw-hours.

Montgomery Creek (Shasta county).—The Mt. Shasta Power Co. at Big Bend has commenced construction work on a seven-mile tunnel that is part of the project for the development of 200,000 horse-power. Two air-compressors are at work and a third is being added to the installation.

San Diego.—The San Diego Con. Gas & Electric Co. has applied to the Railroad Commission for permission to issue bonds in the sum of $250,000. A portion of these funds is to be utilized for reimbursing the company for capital expenditures and the balance for plant extensions.

Boise City, Idaho.—It is announced that the power interests controlled by C. L. Talmadge of New York, and his associates, will undertake the development of a large power and irrigation project in connection with the Beaver River Power Co. Slick Bros. Construction Co. of Boise are contractors for part of the work. Twenty thousand horse-power will be developed.

Irrigation and Water Supply

San Francisco.—The Sutter-Butte Canal Co. has applied to the Railroad Commission for permission to issue bonds in the sum of $129,000 to be used for liquidating indebtedness and for extending its service.——The Railroad Commission has authorized the city of San Diego to purchase the Southern California Mountain Water Co. for the sum of $2,500,000 and to lease the various plants of the system for ten years at an annual rental

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of $67,500, with an option to purchase at $1,500,000.——The Feather River Mutual Water Co. has been incorporated for the purpose of furnishing water for irrigation and domestic purposes to residents of townships 18 and 19 in Butte county. The authorized capital stock is $100,000, and the incorporators are George L. Walker of Alameda, Lewis A. Hilborn of Oakland, H. W. Hartman of San Francisco, Frank I. Guilford of Oakland, and E. W. Price of San Francisco.

Sacramento.—The Cosumnes Irrigation Co., in which James M. Berry, R. T. McKisic of Sacramento, W. E. Kleinsorge, T. L. Gates of Vacaville, and R. A. Berry of Berkeley are interested, will undertake the reclamation of the tract of land lying south and east of Sacramento along the Cosumnes river, between Cosumnes and Galt; 40,000 inches of water has been claimed on the middle fork of the Cosumnes river. Reservoir sites have been acquired capable of storing 30,000 acre-feet. Offices, in charge of E. R. Walker, have been opened in the Ochsner building.——Granville Moore of New York and Rufus Thayer of San Francisco, representing Eastern capitalists, have undertaken a reclamation project including 35,000 acres of land situated in Sutter basin, lying between the Feather river and the proposed U. S. Government by-pass.——A reclamation district has been formed to reclaim property on the north side of the American river between its mouth and the Northern Electric bridge, 730 acres is included in the project, and C. M. Phinney is engineer. The various interests included are controlled by the North Sacramento Land Co., Mrs. John Judge, Katharine Meister, Natomas Consolidated, D. Flint, and Katharine Harget.

Martinez.—A syndicate of Oakland capitalists, headed by Robert N. Burgess, is contemplating the purchase of 10,000 acres of land, including the Johnson and Cope ranches in the Tassajara valley. The property will be subdivided and placed upon the market in small lots.

Montague (Siskiyou county).—The Siskiyou Irrigation Co., for which Messrs. T. H. Means and L. W. Symmes are engineers, is making a preliminary survey from Klamath hot springs for the purpose of laying out ditch lines for irrigating purposes in that section. The men interested in the company are Edward O'Conner, J. S. Foulks, G. W. Dwinnell, J. E. Beaudroit, and T. J. Nolton. Water will be taken from the Klamath river for use in the Shasta valley.

Red Bluff.—Mrs. Mary E. Fourtier has employed Norman R. Smith as engineer to make surveys and estimates for utilizing the waters of Old Cow and South Cow creeks in Shasta county for irrigation purposes.

Lodi.—Messrs. Bridgeman and Keeney, real estate dealers of this town, have sold 2500 acres of the Sargent estate to San Francisco capitalists. This land will be subdivided and placed upon the market in small farms.

Los Angeles.—The Posos Valley Water Co. is contemplating the installation of an irrigation system to cost $250,000 near Posos valley, Arizona. O. L. Grimsley is president and general manager, H. Groves is vice-president, William P. Bardshar is secretary, and G. A. Scroggs is treasurer. The executive offices of the company are at 415 Union Oil building, Los Angeles.——Specifications have been adopted and bids will be received on October 15 by the Los Angeles Aqueduct Commission for the construction of a 6-ft. diameter steel tube, 65,000 ft. long for connecting the San Fernando reservoir with the Franklin canyon power station. Approximately 7964 tons of pipe will be required for the various irrigation districts, including a supply of 2500 inches for Los Angeles city. The maximum water to be carried by the tube will be 9000 inches above the first point of diversion. William Mulholland is chief engineer.

Streets and Roads

Sacramento.—Bids were opened on September 23 for constructing three sections of roadway, under the $18,000,000 highway bond issue. One section in Sacramento county will extend from the Sylvan schoolhouse on the Auburn road to the Placer county line, a distance of two miles. The lowest bid was made by Burns, Clark & Darosa, of Sacramento, amount $9159. The section in Placer county is from the south boundary of the county and extends to Lincoln, a distance of approximately 12 miles. The lowest bid was made by Burns, Clark

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& Darosa, of Sacramento, amount $59,629. The section in Merced county is to extend from Arena to Merced, a distance of 17 miles. The lowest bid was made by the Worswick Street Paving Co., of Fresno, amount $57,594.——W. F. McClure, state engineer, has estimated that $20,000 additional will be required to complete the highway now under construction along Lake Tahoe on the California side to connect Tallac and McKinney. The State Legislature is to be asked to appropriate this amount at the next session.

Riverside.—The Board of Supervisors of Riverside county has appropriated $75,000 for permanent road work during the ensuing year.

Railways

San Francisco.—The Ocean Shore railroad has decided to experiment with the operation of electric storage-battery trains, in order to determine whether economies cannot be achieved by substituting this method for steam equipment which they have been operating in the past.——The Burlingame Electric railroad has commenced construction work. It will connect at Easton on the Southern Pacific and run west through the various Easton additions to the foothills. The storage-battery type of cars is to be used, and it is said that the line will be in operation about the middle of November. The line is eventually to be extended to a point between Lake San Andreas and Crystal Springs. The Easton and Crocker estates are interested.

Los Angeles.—The City Council is planning the construction of a municipal railway to run between the Plaza and San Pedro harbor.

Sacramento.—Surveying for the line of the Sacramento Valley Railroad Co. is practically completed, the only strip of unsurveyed territory being that between Woodland and Denverton. The Dozier Construction Co. is handling the construction work. It is stated that $230,000 of stock has been subscribed in small lots by Sacramento valley people. The offices of the company are in the Forum building in Sacramento.

Vallejo.—The Vallejo & Northern railroad has resumed operations. Good progress has been made with track laying, and grading operations in Jamison county will begin shortly. T. T. C. Gregory is president.

Tulare.—The Big Four Electric railroad has let contract to Hahn & Son, of San Francisco, for grading 41 miles of the right-of-way.

Juneau, Alaska.—It is reported that the White Pass & Yukon railway has been sold to the Grand Trunk Railway System.

Helena, Montana.—It is stated that the Great Northern railroad will build a line 61 miles long, southeasterly from a point between the stations of Snowden and Mondak, Valley county, to Fairview, Dawson county, and thence southeasterly into McKenzie county, North Dakota, to a connection with another proposed line at the confluence of Cherry creek with the Little Missouri river.

Boise, Idaho.—The Idaho Traction Co. has outlined an extensive program of new work, including the construction of a large increase in trackage and a belt-line interurban service.——The Swan Falls power plant will be doubled in capacity. A transmission line is to be built to connect the Swan Falls plant to the irrigation district south of Mountain Home. A high-tension transmission line will also be built between Caldwell and Nyassa. Construction of the local distribution systems at Star and Eagle, and extension of the systems at Boise, Nampa, and Caldwell have also been authorized.

Panama Canal

The grand total of canal excavation to September 1 was 178,344,405 cu. yd., leaving to be excavated 33,882,595 cu. yd., or a little over one-fifth of the entire amount necessary for the completed canal. The total excavation for the month of August was 2,443,353 cu. yd., as compared with 2,706,223 cu. yd. for the corresponding month in 1911. The concrete work in the spillway of Gatun dam is over 91% completed; 205,298 cu. yd. out of a total of 225,000 having been placed at the close of work on September 7. The trestle on the Colon breakwater had been extended a distance of 11,267 ft. from the main land, leaving about 235 ft. to complete its entire length. A double-track trestle extends from shore for a distance of 10,895 ft., and from that point there will be a single-track trestle to the outer end of the break-

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water. The equipment at Porto Bello for excavating and handling the armor rock has recently been augmented, and it is expected that the present shipment of two barge loads daily will shortly be increased to three and possibly four. Three model 91 Marion steam-shovels and 70-ton Bucyrus shovel, 32 Lidgerwood cars, six locomotives, and four locomotive-cranes are now engaged in this service. Over 92% of the concrete for the locks is in place and the amount at the close of work on September 7 was 3,973,310 cu. yd. out of the total of approximately 4,302,563 cu. yd. About 95% of the concrete for the system of three twin locks at Gatun has been laid, the amount in place at the close of work on September 7 being 1,896,576 cu. yd. out of a total of 2,000,000. Concrete work in the lock at Pedro Miguel is over 98% completed, 876,856 cu. yd. out of a total of 889,827 bucket measurement having been placed at the close of work on September 7. About 85% of the concrete for the system of two twin locks at Miraflores was in place September 7, the total amount on that date being 1,199,878 cu. yd. bucket measurement out of a total of approximately 1,412,736.

Panama-Pacific Exposition

Plans for the general exhibition buildings have been completed and are on exhibition at the Exposition building in San Francisco. Specifications and plans for the construction of wharves are practically completed and bids will be called for within the next two or three weeks. Electricity and steam-heating system for the amusement section and also the water-supply system will be ready for bidders within thirty days. Plans for the machinery exhibit building will soon be ready for bidders, and contract will be let on or before November 11. Contracts for the other buildings will follow at the rate of about two per month. Ten months time for the construction of each building will be the maximum allowed. Contract No. 1, which calls for filling in 71 acres of Harbor View lands, has been completed by the San Francisco Bridge Co. Contract was let March 25 and was completed within 180 days; 1,400,000 cu. yd. of silt was deposited upon the land. Borings for the foundations for the Exposition's palaces are about half completed. Plans for the construction of wharves and bulkheads to form the yacht harbor are completed and bids will be advertized for immediately. The State Board of Equalizers has fixed the tax rate for the Panama-Pacific Exposition for 1912 at $0.044 for every $100 assessed valuation of property.

Miscellaneous Engineering Construction

San Francisco.—Contract for constructing a trestle over Yolo basin for the Oakland, Antioch & Eastern railroad has been let to the Mervy-Elwell company. The trestle will be approximately 2½ miles long.——The Shattuck Edinger company has received a contract for building a drawbridge at Montezuma slough.——The City Engineer has filed a report with the Board of Public Works to the effect that the cost of constructing the building for the two incinerator furnaces will be $142,672.50, while the cost of building and two additional furnaces is estimated at $318,237.50, and for a six-furnace plant complete $467,500.——Plans and specifications for six incinerator plants are in course of preparation, and bids will be called for at an early date.——It is expected that the final steps for the consummation of the sale of 800,000,000 ft. of Government timber to the Sierra Sugar Pine Lumber Co. of California will be consummated by Chief Forester Henry F. Graves about October 1.

Los Angeles.—Plans for the construction of the Second street tunnel have been practically completed. Three sets of plans have been made calling for the single, double, and triple-bore tunnel, respectively, and it is expected that the triple-bore tunnel will be adopted. Estimated cost is from $150 to $175 per lineal foot. Homer Hamlin is city engineer.——It has been announced that the Los Angeles, San Pedro & Salt Lake railroad will spend approximately $20,000,000 for increased dock and trackage facilities at east San Pedro harbor. Four concrete slips, each approximately 1400 ft. long, are included in the plan. The City Council has voted to lend the aqueduct cement plant at Monolith to the city of Santa Monica to be used for furnishing cement for the rebuilding of Ocean Park.——William Mulholland, chief engineer of the Los Angeles aqueduct, has announced that the aqueduct project will be completed and ready for carrying water from the Sierras by January 1. The aqueduct

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proper embraces 243 miles of construction between the head of San Fernando valley and intake north of Independence, Inyo county. Approximately 6½ miles of open ditch in the Alabama hills, 4¼ miles in the Rose valley, 1¼ miles in the Grape Vine division, ¼ mile in the South Grape Vine valley, and 1¾ miles of siphon in the Jaw Bone, Pine Tree, and Grape Vine canyons are incomplete at present writing. Of the tunnels, 1½ miles in the power diversion at San Francisquito remain to be completed.——It has been announced that $175,000 additional funds will be required for rehabilitating the San Pedro water system when it comes into municipal control. The Public Service Commission is to pay $125,000 for the water system as it stands. Bids have already been received for pumping engines, air-compressors, and boilers, at a cost of about $35,000, and assorted iron pipe aggregating $140,000. Award of contracts will not be made until the water system has been turned over to the municipal public service commission.

Sacramento.—A. J. Cheney, chief of Federal engineers, has recommended that permission be granted to the Oakland, Antioch & Eastern railroad to build a bridge over the Suisun bay to Chipps island.——The War Department has granted the application of the Sacramento Lumber Co. for permission to build a wharf on the east side of the river, ¼ mile north of Sacramento. ——Steps have been taken for the establishment of a municipal street rebuilding plant by the city commission.

Oakland.—The San Francisco-Oakland Terminal Railways has asked for bids for the construction of its new mole which will adjoin the Key Route pier on the north. This work involves the construction of 16,000 lineal feet of railroad trestle, 15,000 lineal feet of sheet pile bulkhead, 250,000 yd. of track excavation, 25,000 yd. of earth excavation, and 1700 ft. of double track railroad. The fill will extend from the shore end of the Key Route pier 1110 ft. out into the bay and will be 200 ft. wide.

Richmond.—The plans for new harbor for the city of Richmond involve expenditure of about $500,000. The complete harbor work will cost $1,975,000, but of this amount only $500,000 will be expended at present. A channel 300 ft. wide and with 20 ft. of water at low tide is to be dredged. The material handled will be used for reclamation of about 100 acres of new land for factory sites. W. S. Farley is city engineer.

Niles.—The city of Niles is making plans for the construction of a complete sewer system.

Watsonville.—The Watsonville Navigation & Railroad Co., F. E. Snowdon president, has completed a new wharf at a cost exceeding $100,000. The San Francisco Bridge & Construction Co. was the contractor.

Red Bluff.—The supervisors of Tehama county have let a contract to Jenkins & Wells, of Sacramento, for the construction of a steel bridge to span Elder creek on the Red Bluff and Corning road, for the sum of $9445.

Marysville.—The supervisors of Yuba county have awarded a contract to the Portland Concrete & Pile Co. for the construction of a concrete bridge at the site of the present Parks Bar bridge, for the sum of $31,000, with an allowance of $5000 for extra excavations.

Woodland.—The Southern Pacific Co. has filed application with the supervisors for a franchise to construct a wharf at Washington and a spur track in connection therewith.

Colusa.—The supervisors of Colusa county have awarded a contract for the construction of a bridge over Salt creek to Schaad & Anthony, of Williams, for $2260. Contract for a second bridge over Salt creek has been awarded to R. A. Mann, of Chico, for $2159.

Willows.—Plans and specifications for various roads and bridges to be built under the recent $450,000 bond issue have been adopted by the county supervisors. Bids for the roads were opened on September 30, while bids on the bridges will be opened October 7.

Napa.—The supervisors of Napa county have voted to raise $13,000 by direct tax for the construction of a new span bridge over Transas creek to replace the wooden structure now in use.

Antioch.—Proposed bond issue for $31,000 for general municipal improvements was defeated at the polls by a vote of more than five to one.

Petroleum

The export of illuminating oils by sea from San Francisco port for the month of August was as follows: Illuminating oil, 4,420,987 gallons, valued at $205,300; lubricating

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and heavy paraffin, 27,540 gal., valued at $6523; naphthas, and all other lighter products of distillation, 6306 gal., valued at $100; residuum, 8,250,350 gal., valued at $129,360. Of these exports, Japan took 4,299,890 gal. of illuminating oil, valued at $188,355, and Chile 80,000 gal., valued at $12,000. The latter country took 3,612,000 gal. of gas and fuel oil, valued at $55,900; China, 1,266,850 gal. of a lower grade, valued at $20,085, and Guatemala, 1,050,000 gal. of the same kind valued at $16,250.

San Francisco.—The Union Oil Co. has ordered four new tank steamers at a total cost of $2,000,000. The total carrying capacity of these vessels will be 275,000 bbl. of oil. The first is to be delivered March 1913, and the last one in November 1913. The fleet of this company now numbers 18 vessels. Contracts for the new ships were placed in England.——The Kern Trading & Oil Co., one of the Southern Pacific subsidiaries, has called a special meeting of stockholders, to be held in the Flood building, San Francisco, on October 10, to vote upon a proposal to increase the capital stock of the company from $1,000,000 to $10,000,000. Of the increased capital, $2,000,000 is to be expended at once for extensions and improvements.——A cargo of gasoline from the Dutch East Indies is on its way to San Francisco, consigned to the Indian Refining Co., to relieve the shortage of gasoline in the Pacific Coast market.——The General Petroleum Co. has taken over the entire holdings of the Globe Exploration Co. in North Midway. The land in question includes parts of Sections 4, 9, and 19 in 31-22.——The American Union Oil & Refining Co., capital stock $25,000, has been formed for the purpose of building an oil refinery at Tulare. The directors are all Tulare men, and include R. W. McMahon, J. R. Hitchcock, and H. L. Van Werthern. The new plant is to have a capacity of 1000 gal. of gasoline and 250 bbl. of distillate per day.

Los Angeles.—Pacific Pipe Line Co. has obtained from the United States Government a right-of-way, approximately 38½ miles long, through the Santa Barbara National Forest reserve. County rights-of-way have not yet been secured, as the route has not been fully determined.——The Seaboard Oil and Transit Co., of this city, at a meeting held on September 23, authorized a bond issue of $2,500,000. The total assets of the company are said to be $1,708,446.80 and the liabilities $348,918.50. The property of the company includes about 3000 acres of oil land at Panuco, Mexico, and other holdings in the Kern River, Maricopa, and Templor districts in California.——The 4000-ft. wharf of the Standard Oil Co. at El Segundo will be completed about October 1. Eight pipe-lines will be installed on the wharf for the purpose of loading tank steamers.——Suit has been brought before the United States District Court by S. Minot against the Southern Pacific Co., involving title to 84,000 acres of oil land in Fresno and Kern counties, valued at about $50,000,000.——It is announced that the Midway Gas Co. will have completed its gas pipe-line from the Midway field into Los Angeles by about October 1. The first gas was turned into the lines from the Honolulu wells at Midway on Tuesday, September 17.——J. L. Walsh, of the Great Western Oil Co. at Cleveland, Ohio, is authority for the statement that there are 850,000 automobiles in use in the United States, which require about 14,000,000 bbl. of gasoline per year. As the average quantity of gasoline in Eastern crude oil is about 1 in 11, it will be necessary to refine not less than 150,000,000 bbl. of crude oil per year to produce this amount.——The General Petroleum Co. has bought the entire holdings of the Thirty-Thirty-two Land Co. at Maricopa, consisting of 300 acres on Section 30-32 in 12-23. The price paid was $217,000 in bonds and $54,000 in stock, which remains in escrow on account of pending litigation between the Thirty-Thirty-two company and Mary J. Francis.——The Standard Oil Co. will install an asphalt plant with a capacity of 100 tons per day, at El Segundo.

Bakersfield.—The National Oil & Refining Co., of which George Calhoun is general manager, is contemplating the construction of a refinery in the Midway fields, to be built on Section 24, 32-23, near the site of the General Petroleum Co.'s main camp.

Taft.—The Associated Oil Co. brought in a 40,000,000-cu. ft. gasser on Section 2, 31-23, on September 13.——The W. T. M. Oil Co., of which E. Gillette is superintendent, will install an air-compressor for pumping purposes.——The Mascot lease, of which Mr. Jennings is superintendent, and the West Side Oil Co., of which Mr. Lake is superintendent, will also install compressors, if

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the one erected on the property of the W. T. M. Co. proves to be successful.——The California-Midway Oil Co. reports that by installing an Ingersoll-Rand compressor, the production of the well has been increased from 24 to 65 bbl. per day.

Lost Hills.—Fred Mannell will construct a 1000-bbl. storage-tank. The Standard Oil Co. will build a branch pipe-line from Belridge to the Mannell property.

Visalia.—The United States Government has notified the Visalia Land Office of the withdrawal from entry of 37,121 acres of west Kern county oil lands, which will be developed for the production of oil for consumption by the United States Navy. Fifty-eight sections are included, situated in T. 30 and 31 S., R. 23 and 24 E., Mount Diablo base and meridian.

California oil dividends for August were as follows:

Company.	Rate.	Amount.
Amalgamated	0.005	$ 50,000.00
Amer. Pet. Co., pfd	0.005	8,755.50
do common	0.001-3	39,607.00
Caribou	0.01	8,070.30
Claremont	0.01	5,000.00
Central	0.0075	7,500.00
Columbia	0.01	9,992.26
Home	0.01	5,000.00
Monte Cristo	0.025	12,500.00
*Mount Diablo	0.01½	7,500.00
New Pennsylvania	0.005	5,000.00
*Pacific Crude	0.10	70,000.00
Paraffine	0.01	3,000.00
Republic	0.12	60,000.00
Record	0.01	5,000.00
Rice Ranch	0.015	4,500.00
S. F. & McKittrick	0.01	5,000.00
Sauer Dough	0.0075	2,992.50
Section Twenty-five	0.50	20,000.00
*State Consolidated	0.01	5,000.00
Traders	0.006	9,000.00
Union Oil	0.006	184,743.60
Union Provident	0.006	91,402.02
United Petroleum	0.006	48,450.60
W. K.	0.02	10,000.00
Western Union	0.005	5,000.00
Total Cal. companies		$683,013.78
Mex. Pet., Ltd		320,000.00
Mex. Pet., Ltd., pfd	0.002-3	80,000.00
Grand total		$1,083,013.78

*Unlisted.

The output for August was one of the largest yet seen in the state, and the shipments were correspondingly great. The following is the statement in detail:

San Joaquin Valley.	Barrels.	Daily Av.
Coalinga	1,579,576	50,954.06
Kern River	905,365	29,205.34
McKittrick	506,360	16,334.19
Sunset-Maricopa	510,976	16,483.09
Midway	2,136,322	68,267.16
Lost Hills	116,554	3,759.81
Total	5,755,153	
Coast Regions.		
Santa Maria, Lompoc, Cat Canyon	433,863	13,992.35
Summerland	4,350	140.32
Total	438,313	
Southern Fields.		
Fullerton-Puente	487,196	15,716.00
Salt Lake-Sherman	225,227	7,232.12
Los Angeles City	31,842	1,027.16
Whittier	54,918	1,771.55
Coyote-La Habra	109,089	3,519.00
Newhall	9,478	305.74
Ventura county	59,873	1,937.84
Total	977,623	
Grand total	7,170,989	
Shipments	6,685,106	

The following is the report of gross production and field fuel for August:

Field.	Gross Bbl.	Fuel.
Coalinga	1,644,707	65,131
Kern River	1,080,365	175,000
McKittrick	534,561	28,201
Maricopa	556,725	45,749
Midway	2,208,802	72,480
Lost Hills	124,354	7,800
Santa Maria	442,113	8,250
Fullerton	492,096	4,900
Salt Lake	228,187	2,960
Whittier	57,593	2,675
Coyote-La Habra	109,589	500
Los Angeles City	33,343	1,500
Summerland	4,950	600
Newhall	10,078	600
Ventura	64,872	5,000
Total	7,592,335	421,346

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Hints on Practice

A GOOD POLISH for aluminum consists of a paste formed of emery and tallow, the finish lustre being obtained by the use of rouge powder with oil of turpentine.

A COMPOSITION suitable for filling fusible plugs may be made of 1 part bismuth, 1 part tin, and 1 part lead. This will fuse below 212° Fahrenheit.

IF HEAT is not applied in mixing concrete in cold weather, frozen concrete may get into the mixer. Live steam may be discharged direct into the mixer, or a special mixer may be used in which a fire may be built under the drum.

ACCORDING to J. H. Markley, superintendent of bridges and buildings for the Toledo, Peoria & Western railway, timber trestle stringers covered with No. 26 galvanized iron 17 years ago for fire protection were found to be absolutely sound when the covering was removed for putting in an additional stringer for heavier loads.

THERE are various methods used for extinguishing blazing gas wells. A well at Lone Pine, Pennsylvania, with an 8-in. casing and a capacity of 5,000,000 cu. ft. per day, was struck by lightning recently and the flames lighted the country for miles around, while the heat was so intense that operations near by were impossible. After three days a very simple device gave quick success. By the aid of long ropes a boiler stack, with a base mounted on rollers and guys to keep it upright, was moved over the well, the flame then raging at the top of the stack. A sudden jerking away of the stack made a break in the gas current and the flame went out instantly.

TUNGSTEN contacts wear longer than those of platinum or platinum-iridium. This is doubtless due to the lower vapor pressure. At temperatures at which platinum volatilizes badly, tungsten has a very low vapor pressure. Besides this, the heat conductivity of tungsten is more than twice that of platinum, and as a result, the contact faces do not rise to the same high temperature. In comparison with platinum-iridium alloys, the ratio of heat conductivities is still more favorable to tungsten. In connection with the life of contacts, another important consideration is that of hardness. Tungsten is so hard that it does not batter down at all under the continual hammering which the contacts get in service.

ONE of the parts of an electric locomotive which wears the most is the trolley wheel. In one case it was noticed that a new trolley wheel fitted to a trolley head was worn out very rapidly, and upon examination it was discovered that this was due to the fact that there was too much tension on the trolley. Some time previously the trolley standard had been overhauled and the tension springs set by guesswork. Trolley tension for centre running should not exceed 20 lb., while 25 lb. is sufficient for side running. The tension should be set with a spring balance tied to the trolley rope, care being taken to keep the trolley head at the normal height of the overhead wire. It will then be found to follow the usual inequalities of the line with pressure sufficient for good operation.—*Electrical Review*, August 16, 1912.

THE 'Diesel' cycle may be described as follows: Pure air only is drawn into the cylinder, and this is compressed to a point at which the temperature of compression is equal to or in excess of the combustion temperature of the fuel. The compression is from 350 to 550 lb. per square inch. Just as the piston starts on the next outward stroke the fuel is forced in under a pressure slightly higher than that in the cylinder. The high temperature of the compressed air causes the entering fuel to take fire and burn as it enters the cylinder, just as gas burns when issuing from an ordinary gas burner. This does not increase the pressure in the cylinder and no explosion takes place. The pressure, however, does not fall so rapidly during the admission of the fuel as it rose during the compression, and the expansion curve is therefore slightly higher in pressure than the compression curve. The exhaust takes place at a pressure near that of the atmosphere, and very little power is lost through the exhaust gases escaping at a comparatively high pressure as they do in the four-cycle motor.

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Engineers' Note Book

Some Worm-Gearing Formulae*

By H. W. MELLOR

A good deal has been written about the efficiency, tooth contact, applications, and manufacture of worm-gearing, but one rarely sees the formulae connected with their design and performance concisely stated, though they are every-day requirements of many draughtsmen. It is surprising how difficult it is to remember how to calculate, say, the end thrust on a worm-spindle when the motor power driving the spindle is known, or how to calculate the pressure on the worm-teeth at right angles to the axis of the worm when the load only on the worm-wheel teeth is known. The method of calculating it may be known, but one is very liable to make a mistake when setting it down, and to wonder whether or not to take into account the efficiency of the gear.

My aim, then, is to set down the various formulae both for the case when the motor power alone is known, and also when the worm-wheel tooth pressure is the known quantity.

Let—

Lead = pitch × number of threads.

$$\text{Tan } \alpha = \frac{\text{Lead}}{\text{Circumference of worm}}$$

Tan ρ = coefficient of friction.

($\rho = 2\frac{1}{2}°$ is a good average for cut gear in oil.)

(a) Given the power in the worm shaft, or horse-power of motor if the worm is on the motor spindle; then—

(1) Pressure on teeth of worm in lb. at right angles to axis of worm

$$= \frac{\text{H.P.} \times 33{,}000 \times 12}{\text{R.P.M.} \times \text{circ. of worm in in.}} = \text{A}.$$

(2) Pressure on teeth of worm-wheel, also end thrust on bearing.

$$= \frac{\text{A}}{\text{Tan } (\alpha + \rho)} = \text{C}.$$

(3) Load in lb. to cause bending moment on worm spindle

$$= \sqrt[2]{\text{A}^2 + 0.268\ \text{C}^2} \text{ approx. for teeth as below.}$$

This takes into account the force due to the shape of the tooth and that due to the angle of the thread of the worm, which two forces act at right angles to each other.

(4) Twisting moment in in.-lb. in worm spindle =

$$\frac{\text{H.P.} \times 33{,}000 \times 12}{\text{R.P.M.} \times 2\pi} = \text{A} \times \text{rad. of worm in in.}$$

(b) Given the load in lb. on the worm-wheel teeth = C; then—

(1) Pressure on worm teeth in lb. at right angles to axis of worm

$$= \text{C tan } (\alpha + \rho) = \text{A}.$$

(2) End thrust on bearing = C.

(3) Load in lb. to cause bending moment on worm spindle.

$$= \sqrt[2]{\text{A}^2 + 0.268\ \text{C}^2} \text{ approx. for teeth as below.}$$

(4) Twisting moment in in.-lb. in worm spindle

$$= \text{A} \times \text{rad. of worm in in.}$$

(5) Pressure on worm teeth as in case (1), but where wheel drives worm

$$= \text{C} \times \text{tan } (\alpha - \rho).$$

$$\text{Efficiency with worm driving wheel} = \frac{\text{Tan } \alpha}{\text{Tan } (\alpha + \rho)} \times d.$$

$$\text{Efficiency with wheel driving worm} = \frac{\text{Tan } (\alpha - \rho)}{\text{Tan } \alpha} \times d.$$

d = say, 0.97 for bearings and ball race.
= say, 0.95 for bearings and thrust collars.

The tooth is assumed to have an angle of 15° Tan. 15° = 0.268.

For teeth at an angle of $14\frac{1}{2}°$, substitute $0.258\ \text{C}^2$ for $0.268\ \text{C}^2$ in (3).

Cost of Sheet Piling

It is difficult to estimate the cost of sheet piling without inspecting the ground. A fair average allowance is 20 cents per cubic yard for shoring pieces put in about 4-ft. centres in reasonably good ground to a depth of, say, 8 ft., with continuous planking in bad ground $1, for the worst soil to a depth of 12 ft., $3 ought to be enough. These figures are to be added to the regular cost of excavation.—*New Building Estimator by Wm. Arthur.*

*Abstract from *Mechanical World*, July 26, 1912.

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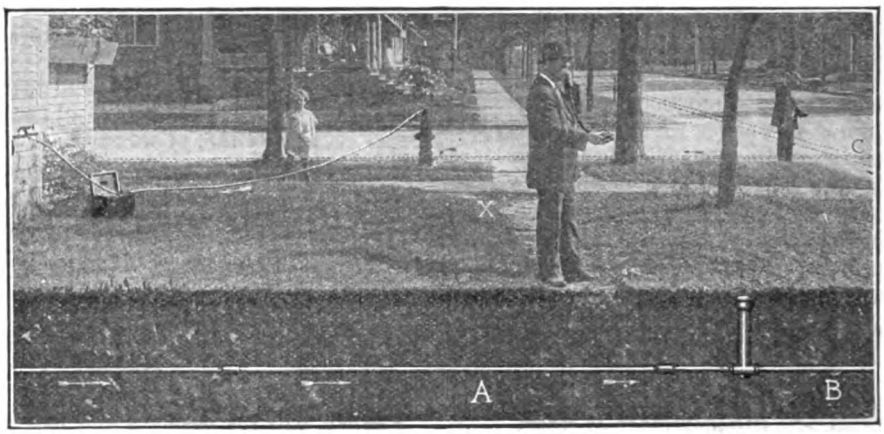
Industrial Progress

Device for Locating Underground Pipes

In many water-works systems there are mains and service pipes whose exact position is not known and not on record, and when repairs or new connections are to be made there is loss of time, money, and labor in trying to locate the pipe by trenching at different points. Electric devices have been invented to enable the exact location to be determined from the surface of the ground, and some of these have been found very successful in practical work. One of these is based on the principle of causing a slight flow of electric current in the pipe, which thus becomes a conductor. When an electric coil is brought within the electric field of this conductor, a current will be induced in the coil and cause a sound in a telephone receiver connected to the coil. The sound increases or decreases as the coil is carried nearer to, or farther from, the underground conductor, but ceases when nearest to it (that is, directly over it). In using the instrument, wires from a small portable battery are attached to suitable connections, and the operator (with instrument in his hand and receiver at his ear) walks to and fro across the supposed line of the pipe, the exact line or position being indicated by the absence of sound, while his approach to, or departure from, this line is indicated by varying intensity of sound. To locate a service pipe, the battery wires would be connected to the house cock and hydrant, thus creating a current along the service pipe. This device is manufactured by the Modern Iron Works, of Quincy, Illinois, and is used by a large number of water departments and water companies.

The illustration shows the method of using this apparatus. In this instance we will assume that it is not known to which main the service is attached to supply the house on the corner lot. The circuit is formed by connecting one side of the instrument to the sill cock and the other to the fire hydrant. On closing the battery the circuit will flow as shown by the arrows. The man in the foreground can hear the tone anywhere in the field formed by the pipes and the wires, but in passing over the service pipes or main an abrupt change in tone is noticeable. By stopping where these changes take place, the operator will be standing almost directly over the pipe. It is a well known fact that a conductor carrying an electric current is surrounded by what is known as an electric field. If a properly-constructed coil is brought within this field an electric current will be induced in the coil. If the coil is connected to a telephone receiver, the effect of the current will be manifested by a tone produced in the receiver. The nearer the coil is brought to the conductor the louder the tone. The Wireless Pipe-Locator consists of a special form of vibrator and induction coil mounted



METHOD OF USING PIPE-LOCATING DEVICE.

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in a box provided with space for the necessary battery. A specially constructed detector coil and receiver is provided for tracing the circuit. An instance of its successful operation is the case of the Champaign & Urbana Water Co. of Champaign, Illinois. The First National Bank had a leak in the ¾-in. service to its building, and as the bank was erecting a new building and desired a larger service, it was desirable to turn off the old service at the main. The slight amount of information available regarding the old service only served to perplex the water company. The only information available was that the service did not run straight out to the main. As the service was under the pavement, it would have been a difficult matter to locate it in the ordinary way. The pipe-locating device was taken to the work, where one wire was connected to the old service and the other to the new service which had been installed. Connection could have been made to the fire plug had the new service not been available. The current was then started, flowing out through the old service along the main and back through the new service to the pipe-locator battery. The current-generating portion of the device consisted of three or four ordinary dry cells and a coil for boosting the current. The operator then took the locator, consisting of a coil wound around a core, and connected to a receiver similar to a telephone receiver. The coil was held so that it was level with the ground, and when in the field of the lines of force sent out by the current through the pipe, and not directly over the pipe, a current was set up in the coil which caused a singing in the telephone receiver. This effect is caused by the lines of force cutting the coil diagonally. When directly over the pipe the lines of force cut the current at right angles, the coil being level with the ground, and no current is started in the coil. It is a simple matter to follow the lost pipe when it is known that directly over the pipe no noise is heard and that to one side (even so small a distance as three or four inches) a noise is heard. Starting from the known location at the point where the connection was made, the periodical interruption of the noise caused by passing directly over the pipe enabled the pipe to be followed under the pavement and finally located where it tapped the main. This was accomplished by swinging the coil back and forth. The accuracy of this instrument was proved by striking the tap in the smallest hole that could be dug in the pavement to the main. Ordinary automobile storage batteries may be used to furnish the necessary current if available. Many of the largest corporations on the Pacific Coast are using this device, among them the San Diego Gas & Electric Co. of San Diego, California.

Motor Trucks in Army Maneuvres

Two important army tests in which Mack and Saurer trucks have been conspicuous in the summer of 1912 were the National Government maneuvres in Iowa and Wisconsin held early in June, and the Connecticut maneuvres recently brought to a close.

The western maneuvres were made over a route that was especially constructed for the difficulties of operating motor vehicles, and in these tests trucks of from 1 to 3 tons live-load capacity were employed. The object of the tests was to determine how far from the base of supplies the army could be maintained with trucks as a means of transportation, likewise to ascertain the practicability of motor trucks operating over irregular highways; that is, crossing fields and maneuvring through timber and brush. The regulations were exactly the same as would prevail in actual warfare. Regular highways were never used in transporting supplies, and naturally these regulations caused many difficulties.

The International Motor Co., New York, had two entries in the western maneuvres—a Mack standard 1½-ton truck and a Saurer 5-ton model. The Saurer was the same type of machine which has competed annually for the French war department subsidies since 1904 and which has never failed to win the first honor in its class in the European trials. The Mack 1½-ton truck was used as a substitute for the regulation camp-wagon, and followed the mule-drawn wagon in the line of march, and as the infantry set the pace which could not be exceeded by the truck, it is obvious that this was a very exacting test for a light type truck to run three or four miles an hour as a steady pace. The Saurer truck was used for carrying the supplies between the army's base and the command.

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Personal

ALBERT GIVEN has been appointed city engineer of the city of Sacramento.

GEORGE N. RANDAL, formerly city engineer of Sacramento, has been appointed city superintendent of streets in that city.

HERMAN SCHUSSLER has been appointed consulting engineer for the Pacific Gas & Electric Co. in connection with the South Yuba dam and power project.

ELWOOD MEADE, chairman of the water supply commission of the state of Victoria, Australia, who has been in the United States for several weeks, has returned to Australia.

C. E. GRUNSKY has been appointed consulting engineer to the Commissioner of Public Works at Sacramento with respect to the flood control project on the Sacramento river.

ACTING GOVERNOR WALLACE of California has appointed George C. Pardee of Oakland, Francis Cuttle of Riverside, J. P. Baumgartner of Santa Ana, Harold T. Power of Auburn, Louis R. Glavis, Miles Standish, and G. X. Wending of San Francisco, D. P. Simmons, Jr., of Los Gatos, W. A. Beard of Sacramento, R. J. Swales of Fort Bragg, Robert L. Hargrave of Madera, and Francis J. Heney, delegates to the National Conservation Congress which meets on October 1 at Indianapolis.

Obituary

JAMES H. WISE, assistant manager of the Pacific Gas & Electric Co. died at Oakland, California, on September 16 as a result of burns received while endeavoring to repair a leak in the gasoline tank of an automobile. Mr. Wise was thirty-three years of age and a graduate of the University of California with the class of 1903. After teaching mathematics for a year at the California School of Mechanical Arts he entered the employ of the Pacific Gas & Electric Co. in 1904, where his rise was rapid, he having been successively instrument man, assistant to the consulting engineer, and finally assistant general manager, having entire charge of the construction and extension of the steam and hydro-electric divisions of the work. His untimely death has brought to a close a career of exceptional promise.

Society Meetings

THE convention of California municipalities was held at Berkeley, California, September 23 to 28. Among the men taking a prominent part in the proceedings were C. D. Marx of Stanford University, C. J. Derleth, and Robert Sibley of the University of California, Percy V. Long of San Francisco, P. H. Haviland, county surveyor of Los Angeles, Dr. F. W. Browning, of the State Board of Health, and city engineers, Byxbee of Palo Alto, Bailey of Pomona, Noyes of Vallejo, and Brownfield of San Mateo. Many notable papers were read dealing with engineering and sanitary conditions existing in municipalities and ways and means for their improvement.

MEMBERS of the International Chemistry Congress arrived at Bakersfield on September 30, and are being conducted through the oilfields under the auspices of the Kern County Board of Trade. The members present include J. A. Adan, Robert Adan, Richard Brandeis, H. Burcherer, Wilhelm A. Clemm, Winthrop C. Durfee, Philip S. Durfee, David T. Day, Siegfried Erbsloh, Edward Erlenbach, Paul Eschert, W. Gerhardt, R. Guilini, George Grube, Bernard Goldschmidt, H. Hahle, Victor Haenisch, Hugo Henkel, Karl Hintz, Rudolf Hoffmann, Josef Hubert, Gustav Keppeler, Henry J. Krebs, Paul Kurtz, Eberhard Kayser, B. Koehler, Edward Markwald, Julius Mauthner, Botho Mulert, H. E. Mueller, W. Muller, E. Parrow, K. Quasbart, Paul Reidel, George D. Rosengarten, Johannes Schultze, Leopold Singer, Leo Steinschneider, Gehard Storek, Johannes Schmidt, Rudolph Sack, Werner Sack, Edwin Storek, J. Thiele, D. Vorlaender, Alexander Wacker, F. A. Weber, N. Wense, J. J. A. Wijs.

New Publications, Bureau of Mines

BULLETIN 18. 'The Transmission of Heat In Steam Boilers,' by Henry Kreisinger and W. T. Ray. 1912. 180 pages.

TECHNICAL PAPER 17. 'The Effect of Stemming on the Efficiency of Explosives,' by W. O. Snelling and Clarence Hall. 1912. 20 pages.

TECHNICAL PAPER 18. 'Magazines and Thaw-Houses for Explosives,' by Clarence Hall and S. P. Howell. 1912. 32 pp., 1 plate.

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